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INTRODUCTION

TO THE

STUDY OF NATURE;

ILLUSTRATIVE OF THE

ATTRIBUTES OF THE ALMIGHTY,

AS DISPLAYED IN THE CREATION.

BY

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&c. &c. &c.

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PREFACE.

THE unspeakable importance of the study of Nature, when properly directed, and the almost unlimited extent of the phenomena which it embraces, as well as of the enquiries to which these phenomena give rise, and of the illustrations by which they are explained, seem to render any apology for the publication of the following pages altogether unnecessary.

It is true that the Author only follows in the track of others; but it will scarcely be alleged, that a field so wide is already preoccupied, or that the number of labourers is too great. He assumes not the character of a rival, desirous to supplant; but of an humble coadjutor, willing to lend his feeble efforts to so good a cause,—happy if he shall, in any degree, contribute to kindle or to foster, in the ingenuous mind, a desire to become better acquainted with the wonders of creation; and, in these wonders, to read more clearly the perfections of the great Creator.

The particular task which he has assigned to himself is, that of presenting the most familiar appearances, under the aspect of facts which solicit attention, and amply repay investigation; that he may show how entirely within the reach of every man are those studies which enlarge the sphere of useful knowledge, while they afford the most interesting employment to the understanding, and improve the heart.

It did not, therefore, accord with his plan to confine himself to the consideration of any one department of Nature; or to be fastidious as to the scientific arrangement of the various subjects which came under his review. These subjects are treated rather in the form of distinct and independent Essays, than as different steps in one unbroken argument; and yet, he shall have but ill accomplished his object, should not the whole of his investigations, various and desultory as they may appear, be found to bear on one great conclusion, and *that* the most important to which unassisted reason can come,—namely, that the hand of a wise and intelligent Creator is every where visible, demanding the reverence and adoration of his rational creatures. Nor shall he have less failed in his aim should he leave the mind satisfied with this discovery, or unprepared to seek, in revealed reli-

gion, an answer to those mysterious questions, which Nature anxiously proposes, but cannot solve.

In conclusion, the Author has to remark, that he is indebted for much of the substance of the Chapters on Zoology, and the Adaptations in the formation of Animals to their appointed modes of life, to Notes, taken while attending the Lectures on Physiology, of Dr. Fletcher of Edinburgh. It must at all times afford him pleasure to acknowledge the benefits he received from that gentleman's instructions, and the colouring which they have given to his own opinions and practice.

DUMFRIES, 1834.

CHAPTER I.

THE LOVE AND STUDY OF NATURE.

It is not less instructive than it is interesting to examine the formation, and functions, and histories of animate and inanimate bodies, and to trace out their various relations to each other; and to whatever branch of this study we apply our minds, in the spirit of candid enquiry, we cannot fail to discover adaptations, so wise, so beneficent, and sometimes so surprising, that it is impossible to resist the evidence of a Divine hand, or to withhold the tribute of the profoundest veneration.

Among these adaptations, that of external nature to the powers of the human mind, has lately been treated with much eloquence and felicity by a deservedly celebrated author; but I do not remember that, in his varied illustrations, he has noticed that beneficent provision in the moral and intellectual constitution of our race which affords them a relish for the very enquiry he has so successfully prosecuted, in one of its most important departments.

It is not easy, however, to turn our attention to this subject, without being struck with admi-

ration at the wisdom which it unfolds. Man is destined to be long conversant with external objects ; it is, therefore, of essential importance that these objects should be calculated to please his taste and to interest his affections. Were it otherwise, he might still indeed be stimulated to exertion by the cravings of hunger; but he would be deprived of all that is generous in his motives and elegant in his employments. His mind would be cold, morose, and intensely selfish ; and, through the whole period of his history, he would be doomed to remain a worthless and brutal savage.

To save us from this degradation, we are endowed with various feelings and propensities, which receive an ennobling gratification from the sensible objects with which we are surrounded.

In childhood it very early appears that there is a peculiar pleasure resulting from the mere exercise of the different senses. The mother, as she fondles her infant offspring, traces the first dawn of intelligence, not merely in the eagerness with which he seeks the delicious food that nature has provided for him, but in the eye which courts the cheerful light of heaven, and the ear which delights in harmonious sounds and tones of kindness, and the hand which gladly seizes the bauble which affection offers. Nor is this simple and primary source of enjoyment less distinctly indicated in the innocent smile which plays upon his little cheek, as objects flit before

him, or the chuckle of transport with which he replies to the fond arts of parental endearment.

But other faculties of a still less equivocal nature are quickly developed. Curiosity, and a desire of possessing, are among the first propensities which strongly move the infant mind; and these, while they prove the powerful hold that external nature takes of the young affections, appear evidently to be implanted as the means of calling the mental and bodily powers into vigorous action, and of preparing the tender child, by a salutary discipline, for the sterner employments of manhood.

It is edifying to observe how these two principles operate in producing this salutary result. The love of possessing extends the eager arm, and teaches the hand tenaciously to grasp, and the eye to guide it surely and directly; while curiosity employs all the senses, assisted by the judgment, in a minute and unwearied examination of the objects possessed, until their various sensible qualities are ascertained and treasured among the stores of memory. Hence, along with the first rude ideas of property, a fund of useful information is acquired, always accumulating and becoming more important; and as infancy passes into boyhood, and boyhood into youth, imagination, gaining strength, lends its enchanting power to give intensity to the mental energy, and shedding over every new discovery the warmth of its colouring, kindles and fosters the Love of Nature in the susceptible heart.

To all this may be added another faculty, which without attempting accurately to analize it, may be described as that which affords to the mind the perception of natural beauty and grandeur. This fine emotion, which is distinguished by the name of Taste, on whatever ultimate principles it may depend, is, doubtless, the chief source of the pleasure arising from the contemplation of natural appearances. We perceive objects lovely in themselves, or lovely in their combinations, and our hearts warm with a very peculiar and elevating enjoyment;—we perceive objects sublime from their vastness, or magnificent from combined splendour and greatness, and immediately within us sentiments arise of wonder and astonishment, or of awe and veneration. Who can find words to express the delight he has experienced from contemplating the beauties of a summer landscape, when the shades of evening were falling sweetly and tranquilly around; or the sublimity of the starry heavens, when the darkness of a winter night gave depth to the etherial blue of the firmament, and brilliancy to the innumerable worlds which gemmed that boundless canopy?

The Love of Nature, then, is a complex feeling, arising from different qualities of the mind, mysteriously combined, and with which external objects have been made to harmonize, so as to call them into powerful exercise, and cause them to be a source of exquisite and varied enjoyment; and it is useful to trace the adaptations

by which this beneficent system has been constructed.

It is easy to conceive a world whose appearances and various relations would offend our taste, and be altogether discordant with our feelings, as well as unsuitable to our powers and faculties; nor is it possible to doubt that the disgust or apathy arising from this unhappy contrariety, if it did not lead to utter extermination, would at least deeply affect the character, and entail misery on the lot of humanity.

It is, therefore, no insignificant proof of an intelligent and bountiful Creator, that there should exist so harmonious an agreement between mind and matter,—that the powers of the one should be so wonderfully adapted to the aspect and qualities of the other, and that the happy combinations which are thus effected should be productive of such high and rational enjoyment.

It must not be forgotten, however, that although such suitableness between the mental powers and the phenomena of the external world actually exists, it partakes of the imperfection inherent in all sublunary things. The fall of man, which has so deeply affected the character, the condition and the mutual relations of the moral and physical worlds, has thrown a mystery over them, which mere human philosophy attempts in vain to penetrate.

We can readily form an idea of a state of things corresponding, far nearer, to our notions

of perfection, than is to be found in the earth we inhabit. It were easy for our imaginations to portray a world in which love, and peace, and joy should universally prevail;—in which the passions of intelligent beings, nicely balanced, should yield without an effort to the guidance of reason and duty;—in which the mental powers should be accurate, penetrating, and unbiassed; and in which external nature, harmonising with this perfection of the moral and intellectual powers, should be always serene, beautiful and exhuberant—blessing the ear with sounds of sweetest melody, charming the eye with sights of uncloying beauty, exhaling the most delicious perfumes, and filling all the senses with endless delight. In such a world the perfections of the great Creator would be openly displayed, and the whole relations of mind and matter would, almost intuitively, exhibit the evidence of wise and beneficent design.

Such was Paradise;—but such is not the present state of our world. A fearful blight has passed over the face of nature, and marks of imperfection and disorder every where perplex the enquiring mind. In the intellectual world there are error and ignorance, fatuity and folly; in the moral world there are passions, prejudices, selfishness, wars, cruelties and innumerable crimes; and in external nature the air, the earth and the sea teem with agents of apparent evil;—whirlwinds and tempests, mildew and drought, with famine and pestilence in their

train, carry desolation abroad—while decay and death fill the world with mourning.

Before we can safely interrogate nature, therefore, there is a previous question of unspeakable difficulty to be settled; namely, what is the end that Providence has in view in the present mysterious order of things? Perfection is not here. Happiness is not here. What then? The answer, in one word, is, "A school of discipline to train mortal man for immortality;" and that answer cannot readily be extorted from nature—it is only to be clearly read in the book of Revelation.

We have thus obtained a principle, which opens a new view of the various relations of mind and matter, and renders the investigation, though not free from difficulties, at all events in some of its bearings, within the grasp of human intellect. The adaptations which we now look for are of a lower kind; they are not perfect, but apposite—not absolute, but relative. We expect a system which may train weak and erring creatures, by various gradations, to excellence, and may fit them, by the combined operation of moral and physical means, for a higher state of existence; embracing evil, but overruling it for good; employing pain, disappointment, calamity, and even death itself; but converting them into instruments of happiness and immortality.

Such a system is necessarily more obscure and more complicated than that which excludes the agency of evil; and, on tracing its operation,

the half informed mind can scarcely avoid being occasionally involved in difficulty, and harrassed with doubts; but when rightly understood, it affords the most surprising and beautiful displays of an all-pervading goodness and wisdom. It may be impossible for unassisted reason to understand why evil should be permitted to exist in any form, under the administration of a Creator and Governor of infinite perfection; but that it does exist is undeniable. Adopting, therefore, the fact, and resting its history on the declarations of revelation, where the only satisfactory explanations of it are afforded, what remains for the philosopher is to exhibit the amazing contrivances which Divine wisdom has adopted for mitigating inherent defects, and converting them into blessings.

We have thus seen that the love of external nature is a principle, for wise and evident reasons, implanted within us; and, looking abroad, over the vast and various nations that inhabit the different regions of the globe, we find that men of all ages, wherever they be placed, and by whatever government they are ruled, loving and venerating external nature. If we revert to the bright and golden ages of antiquity, man presents himself to our view as surveying, with the delight and wonder of a curious child, the scenes by which he is surrounded—the stern and solitary mountain—the lonely and untrodden wilderness—the foaming cataract and the desolate shores of ocean; as astonished and overwhelmed

with awe at the cloudy majesty of the tempest, or the bright glories of the noon-day sun; as listening to the voice of the thunder, or to the rolling of the distant torrent, descending from the lofty mountain's side; and, as falling down in lowly admiration of the Ruler of the earth, the sea and sky. Full of the Love of Nature, and absorbed in the contemplation of the beauties and wonders which, in every variety of aspect she unfolds to his view, he yields to the guidance of his imagination; on every side he beholds a God, he hears his voice in the thunder, and sees his red right arm made bare in the lightening.

Turning to the immortal land of the Greeks, we behold in their beautiful, and varied, and highly imaginative mythology, the intensity of the love and admiration of external nature which they possessed. They embodied, in delightful allegories, the loftiest conceptions of the universe and the origin of things, exalting them as objects of awe and of the admiration. Night, and darkness, and old chaos, and heaven, and earth, and all the powers and elements of nature, they personified in their mystical imaginings, giving to

> "many an airy nothing
> A local habitation and a name."

Their numerous divinities, and all that was grandest, and holiest, and dearest in their religion arose from nature. In Jupiter was embodied forth the majesty of the heavens; in Neptune the alternate storm and tranquillity of the sea;

and in Pluto the darkness and horror of imaginary eternal gloom. Inanimate nature, too, was represented by a fanciful, but most beautiful mythology. What classical reader has not been charmed with such grotesque and fanciful beings as Pan, and Pomona, and Flora, and Vertumnus, all creatures of imagination, sweetly breathing of their fresh and flowery domains? Or, who that ever tasted the pure waters of ancient poesy, and imbibed the peculiar feelings and joys of the olden Grecian times, has not beheld, in fancied vision, the wild nymphs of the mountains, or the Dryads and Fauns sporting amidst the sylvan scenery of the untrodden grove, or the Naiads pouring from their urns the limped fountains, or the Neraids moving along the ocean, where Triton blows his hollow-sounding shell, and Proteus drives his herd to pasture on the waves? But looking upon the moral world, wherever it is presented to our view, we find the Love of Nature universally manifested, and equally exerting its power, in the breast of the untutored savage and refined European. In the North American Indians, a passion for nature is a predominate feature; and to say that any intelligent peasant,

> "Brushing with hasty steps the dews away,
> To meet the sun upon the upland lawn,"

beheld his rising with indifference, and all the beauties of the morning scenery, unconscious of delight, were to do great injustice to his character. It is evident, therefore, that we are fitted,

by our mental constitution, for the study of those wonders which a Divine hand has every where scattered in such profusion around us; and surely no one will be found who thinks that such an adaptation has been afforded us without a point, an end, a meaning, or a destination; on the contrary, all must acknowledge that the study and contemplation of nature, while it tends to gratify a laudable curiosity, and to fill the mind with a rational delight, is calculated, in no trifling degree, to improve the understanding, and to give scope and vigour to all the powers of the mind.

In the mere gratification of our taste for the study of nature, viewed in its various phases and arrangements, there is not only enjoyment, but the means of mental cultivation. Taste has been sometimes considered as nothing but the application to external nature of that faculty, which, in morals, enables us to distinguish between right and wrong—the beautiful, in objects of sense, being supposed to be perceived by the same operation of the mind, which distinguishes what is proper and becoming in the intercourse of society; but without adopting this opinion, we may confidently assert, that, from the exercise of the former, a salutary effect upon the character results, somewhat analogous to that which arises from the exercise of the latter.

The man who has been accustomed to cherish a Love of Nature, and eagerly to pursue her steps, wherever they are to be traced, acquires a habit

of sober contemplation, or of lofty thinking, which gives a firmer tone to his mind, and elevates him above the sordid views and low vices of the vulgar herd with whom he is surrounded. The employments which the necessities of our nature originate, when perverted by an undue indulgence, and a corrupting intercourse with our fellows, into incentives to cupidity, selfishness and cunning, as well as the mean pleasures to which such vicious propensities give rise, seem uncongenial to the mind which seeks for gratification in so grand and elevated a field. There is assuredly something ennobling in the cultivation of those feelings which lead us to traverse the undulating valley, or to linger in the sylvan glade, when the plastic hand of Spring clothes the fields and woods in the softest green, and "the time of the singing of birds is come;" and when glowing Summer sheds her profusion of flowers and perfumes; and when Autumn waves her golden harvest, and tinges the trees with her russet fingers; and when Winter spreads over expiring vegetation his snowy winding-sheet, and howls through the desolated forest; or which lead us to seek the grandeur of the lofty mountain, the craggy steep, and the foaming cataract; or which induce us to indulge in the sublime enjoyment arising from the war of elements, when the tempest-tost ocean mingles with the sky, and thunder rends the welkin, and lightenings dart their livid fires from pole to pole.

Such a temperament has been sometimes sup-

posed to be the exclusive prerogative of genius, and although the truth of this opinion cannot be admitted, it must be owned that the susceptibility of the poetic mind cherishes most ardently a feeling which the beneficent Creator has deeply implanted in every breast. It is impossible, indeed, not to perceive the justice, as well as the beauty, of the description which the Scottish poet gives of his own youthful admiration of natural sublimity and beauty—

> " I saw thee seek the sounding shore,
> Delighted with the dashing roar ;
> Or when the North his fleecy store
> Drove through the sky,
> I saw grim Nature's visage hoar
> Struck thy young eye.
>
> " Or when the deep green mantled earth
> Warm cherished every flowret's birth,
> And joy and music pouring forth
> In every grove,
> I saw thee eye the general mirth
> With boundless love.
>
> " When ripened fields, and azure skies
> Called forth the reapers' rustling noise,
> I saw thee leave their evening joys,
> And lonely stalk
> To vent thy bosom's swelling rise
> In pensive walk."

These sentiments, although more strongly felt by the poet, and more vividly embodied in his glowing lines, draw a sympathetic response from every heart which has not been debased and brutified by counteracting influences ; and it is

not easy, I would think, to be conversant with such objects, and to derive from them the pleasures they are capable of affording, without retiring from the exercise not only a wiser, but a better man.

The Love of Nature is implanted, not merely for the purpose of humanizing, but of instructing the mind; and he who should content himself with the simple but exquisite enjoyment arising from the faculty of Taste, would but partially and feebly pursue the path pointed out by the propensities which the God of nature has bestowed upon him.

But it is not the mere superficial view of natural appearances which is calculated to engage our attention and interest our hearts. The more eagerly we penetrate into the hidden recesses of nature, and the more importunately we question her, the more astonishing are the discoveries she lays open, and the more readily does she afford a glimpse of the deeper and richer treasures, which lie still beyond our reach, and which farther progress, and more devoted assiduity may yet enable us to attain.

The youthful eye, when it first begins to take a survey of external nature, imagines that it sees and comprehends every thing around it; but, as it gazes, new scenes arise, new combinations appear, new properties are elicited, wonder on wonder fill the admiring view, till at last it is felt that he who sees farthest, and penetrates deepest, only learns that he knows nothing. The mind

is thus at once overwhelmed; and the child of mortality, perceiviug that all is dim and mysterious here below, longs to burst his prison-house and to expatiate in those higher regions, where he shall be able to look through the surface to the essence; and in the immediate presence of his Creator, "to see even as He is seen, and to know even as He is known."

There is no department of natural science which does not amply repay the enquirer for all the zeal and diligence he can bestow upon it, provided only he begin the study in a right spirit, and prosecute it with a candid and an humble mind. Whatever be the subject to which he directs his attention—whether the earth or the skies—whether the great laws of nature, as exhibited in the vast universe, or their minute combinations and relations, in reference to objects with which he is daily familiar—whether the mighty masses of inanimate substances, or the properties of organized matter and beings—in every instance the superficial view to which he was accustomed quickly disappears, and he is introduced, as it were, into a new world, in which he traces more distinctly, at every turn, the footsteps of an intelligent and omniscient Creator; and while his mind is enlightened by new knowledge, his reasoning faculties are strengthened, his views are enlarged, and his moral perceptions become more acute and accurate.

Take, for example, the starry heavens. The

uninstructed regard the tiny lights which twinkle there, as so many lamps, suspended from the azure vault to enlighten and cheer their earthly abode. And, so far as their knowledge extends, they think truly. But he who studies nature, learns that this beneficent provision, so far from being the sole object of Divine intelligence, is one of the least astonishing of those wonders of power, and of wisdom, and of goodness, which astronomy displays. He finds himself placed in a world which, instead of being the centre of the universe, and the largest and the most important of the objects around him, is but an insignificant planet, revolving round a small, and, comparatively, inconsiderable star;—whilst in every sparkling diamond of the sky he beholds a new sun, the source of light and heat to new worlds such as his own; and even these, numerous and glorious as they are, he is taught to consider, when compared to the created universe, but as a small group—a single nebula, amongst the countless myriads of nebulæ which exist in the immensity of space.

What an astonishing view is this, and how redolent of moral instruction to the well regulated mind! If the shepherd king of Israel, in the contemplation of the wonders which sight reveals to the unassisted eye, was, even with his imperfect light, overwhelmed with admiration, and awed into humility, how unspeakably more deep and powerful ought to be the inward sentiment which forces the exclamation from the inmost

soul of the modern Astronomer, "Lord, what is man that thou art so mindful of him, or the son of man that thou visitest him!"

For another example, take the discoveries of the microscope. In the objects presented to our unaided sight, it was always easy to observe astonishing displays of a minute and most beneficent attention to the preservation and happiness of living creatures; but it was not until the invention of the microscope that the *extent* of that providential care was known or even suspected. The savage may be able to trace a regular succession of living beings, from the mite, whose voluntary motions are just discernible by the naked eye, up to man, whose more perfect bodily frame, and nobler mental powers point him out, as beyond all question the lord of the earth; and he may even discover some portion of the curious analogy, which the philosopher has found grounds for believing to exist, among all tribes of animated nature, within the compass of his vision. But, in the microscope, science has presented us with an instrument which has opened to our view a new series of living creatures, to which the mite is as an elephant; and in whose organization and instincts, new, and not less admirable indications of creative wisdom are afforded.

The discoveries which have been thus unfolded, are indeed scarcely less calculated to stimulate our curiosity, and excite our admiration than those of the telescope. With the assistance of these instruments we find the sphere of our

knowledge almost indefinitely increased in two opposite directions; and, while by the one we are enabled to trace in the infinite expanse thousands of new systems, crowded with unknown worlds, and bright with the glories of Omnipotence, by the other we acquire power to perceive the Creator of a universe, minutely busy among the worlds of living creatures, to which he has given birth on a blade of grass, or in a drop of water.

Dr Chalmers, to whom I have already alluded, has, with an eloquence peculiarly his own, drawn from the discoveries of the microscope, an irresistible argument to rebut the specious sophistries of the infidel; who, from the immensity of created nature, would infer, that so insignificant a being as man is below the compassionate notice of the Creator. There is indeed something unspeakably satisfactory in the view this highly gifted divine has taken; and, if at any time our faith is ready to give way, before the infinite majesty of Him who speaks systems into existence or annihilation, we have only to look at the millions of microscopic nations, that we may behold His infinite condescension, and be reassured.

I do not say that among the perversities of our fallen nature there are not to be found counteracting influences, capable of preventing the lesson from being learnt, which the wonders of the external world are intended to teach, and even capable of converting the naturally useful operations of such high instruction, into means of evil.

It is but too true that such an employment may only serve to influence the pride of the self-sufficient, and minister to the rashness of the presumptious; but then it must not be forgotten that such unhappy effects can only be produced in minds previously led astray by prejudice, distorted by passion, or corrupted by vice; and when the importance of preoccupying the mind with right views is considered, the almost total neglect of this department of instruction, in our common systems of education, cannot be too strongly condemned. It is indeed surprising that so obvious a method of opening the youthful mind, and imbuing it with useful knowledge, should not be eagerly seized by the judicious instructor.

In making this remark, I have no intention of reflecting upon the laborious exertions by which the languages and the literature of the classic ages are inculcated; but it is impossible to refrain from observing, that if these accomplishments are only to be obtained by repressing the Love of Nature, inherent in the breast of ingenuous youth, and by deadening the generous curiosity of that early age to become acquainted with the mysterious world in which Providence has placed us, the price which is paid is by far too dear.

It is doubtless owing to the injudicious training of the years of boyhood that so many are to be found, who, notwithstanding the innate tendencies of the human mind, and the wise adaptations, and kindly invitations and allurements of

nature, are found as they advance to manhood, to become more blind to the beauty and grandeur impressed on the objects around them, and less alive to the treasures of knowledge and mental enjoyment, as well as to the proofs of wise and beneficent design with which creation teems.—There must be some radical defect in the discipline by which the youthful mind is cultivated, when the mental eye, as it expands, only sees the hand of its Creator more dimly, and the very faculties which were intended to enable him to view His works, and to receive an exalted enjoyment in the contemplation of His perfections, become more contracted and obtuse, as the means of exercising them become more abundant.

We should pity the man whom we should discover wandering blind and insensible in a splendid museum, amidst the exquisite productions of art; but much more, most assuredly, is he to be commisserated, who, with his eyes open, walks unmoved amidst the wonders of the universe, and casts a "brute unconscious gaze" upon scenes which reflect the glories of the Eternal, and from which the highest created intelligences receive edification and delight.

In following out the views I have laid down in the preceding pages, and aiming more at usefulness than originality, I shall endeavour to embody, in easy and unsystematic essays, such popular views of nature as may lead the mind, without any laborious effort, up to nature's God,

and, enlarging the understanding, may elevate the affections while they improve the heart.

Such a study, I am aware, if prosecuted in all its bearings, leads to deep and abstruse investigations, unsuitable to the habits of the great mass of readers, and not to be engaged in with advantage but by men of literary and philosophical minds. A Bacon, a Newton, and a La Place, appear only at long intervals, to illuminate successive ages; and the humble task of even following in the arduous path which these, and such wonderful men, have opened up, is not within the range of ordinary pursuits, or within the reach of ordinary minds. But if the rich ore of nature lies deep, there are, nevertheless, diamonds and pearls to be found near the surface; and over the whole face of the earth are scattered stores of loveliness, which even a common eye can delight to contemplate, and flowers of surpassing fragrance and beauty, which even a common hand can pluck.

Above all, there are footsteps of a Creator so palpable, that he who runs may read them; and such an exercise is the noblest and most satisfactory in which the human mind can engage. There is indeed something unspeakably grand and affecting in the belief which this study confirms, if it does not originate, that the Almighty framer of innumerable worlds—He who called all things from nothing into existence by the word of his power, and still sustains them in beauty, and order, and harmony, by the wisdom

of his Providence—condescends to notice and to bless the meanest object in his universe;—that the same hand which guides the sun in his daily journey through the sky, and "wheels the rolling spheres" as they cheer the silence of night, gives life and enjoyment to the microscopic insect, and breathes softly on the opening blossom, and spreads the green carpet beneath our feet, and gives grace and sweet odour to the modest flowers which springs to adorn it.

With regard to the Study of Nature, I would shortly observe how necessary and important it is to acquire an extensive store of facts; for, without them generalizations and theories become "mere philosophical webs, woven by ingenuity, the device of which is beautiful, but the fabric too frail to endure the touch." Let us stop but a moment, and behold as it flows, and contemplate in its wonderful, and almost immeasurable extent, with feelings of the most profound veneration, the sacred stream of science. Behold it flowing, at first a small and scarcely noted rivulet, gently and silently gliding through shady and retired glens, and receiving in its progress many as humble and insignificant a rill, till the whole united forms a mighty river, foaming onward in the grandeur of its course, and fertilizing the regions through which it passes; and, like that river must be the student of nature—despising not the humblest fact that presents itself to his observation; though, as the little rill, it may be useless in itself, and alone derive its

value from forming a part of the stream wherewith it is afterwards to be united.

In the following pages, I neither desire, nor shall I attempt to make the reader a profound Naturalist; it shall simply be my province to endeavour to lay before him the leading truths of nature, to lead him to their contemplation, and above all, to induce him to seek out knowledge for its own sake, for such alone must be the motive that actuates him who would successfully devote himself to mental improvement.—"Learning," says Campbell, in his address to the Glasgow students, "is a proud mistress; she will not be courted for our hopes of worldly power, or for our ambition to be allied to her family, or for the pride of showing her in public, without the passion and devotion which we must bear to her sacred self. It springs from our interest in this magnificent and mysterious creation, from our curiosity with regard to truth, and even from our fondness for the airy colourings of fiction. The blessings it confers, too, are no where disputed; for all agree that knowledge is power, and that man *is* what he *knows*."

CHAPTER II.

ZOOLOGY.

DIFFERENCES BETWEEN INORGANIC AND ORGANIC MATTER—NATURE OF LIFE—ANALOGIES IN THE STRUCTURE OF MAN AND OTHER ANIMALS—RELATIONS OF THE FUNCTIONS TO EACH OTHER.

The general division of Matter is into inorganic and organic,—the former including all mineral substances—the latter all vegetables and animals. Both are formed probably by the combination of more or fewer of the same primary or elementary principles; but the characters of the resulting compounds, and the properties which each display, are essentially different.

Thus inorganic matters are of unlimited extent, and are not bounded each by its proper envelope; whereas, such as are organic are comprised within definite limits, and have, for the most part, each its own distinct coat. The form and proportions of the former are, in like manner, generally indeterminate, or, if otherwise, as is the case with crystals, they are bounded by flat surfaces and right lines; while the latter have always more or less definite forms and proportions,

the boundaries of which present in general convex or concave surfaces, describing curved or undulating lines. Again, the association of the several parts of which any component inorganic substance is composed, is, as it were, accidental and arbitrary, so that it may be described as destitute of individuality,—no one part being conducive to the perfection of the whole; whereas, in an organic substance, the association of the several parts is fixed and definite, and each, being more or less essential to the integrity of the whole, contributes thus to its individuality. "The *reason*," says the celebrated philosopher Kant, "of the existence of each part of an inorganized being is to be found in itself, while, in organized beings, the *reason* of the existence of each part resides in the whole;" and this individuality of the latter is the more pronounced, that is to say, they are less susceptible of division without injury, the more complicated is their structure, or, in other words, the more concentrated their several organs have become. Lastly, the texture of inorganic substances, composed as they are, chiefly or entirely of solid particles, is more or less hard or rigid; while that of organic substances, which consist of a large proportion of fluid particles pervading their solids, is, on the contrary, soft and flexible. With respect to the ultimate structure of organic substances on which their texture depends, this, as far as it can be ascertained by the unassisted senses, consists essentially of a spongy substance, called

cellular tissue, forming extremely minute cavities, in which fluids are contained. It is disposed in layers which intersect each other in every possible direction; and, interwoven as it is with various other incidental textures, constitutes what is called the tissues in general,—these combine and form organs—organs combine, and constitute, with the fluids, the entire substance. But both the tissues and fluids of organic bodies are said to be found, under a microscope of high powers, to consist of certain globules of a definite form and size, so that it is in fact of these that such bodies appear to be actually composed. These globules are represented as found both in vegetables and in animals, and, as well in the most rude as in the most perfect species of each. The algæ and fungi among the former, and the infusoria and polypi among the latter, are described as equally containing them, both in their fluid and solid parts; and in the higher species of both plants and animals, they are said to be still more perceptible. Of the former, they are described as existing, not only in the solid tissues, but in the proper sap, and in the fecula, resin, albumen, colouring matter and other substances formed from it; and, of the latter, not only in the cellular, nervous, mucous, serous, fibrous, and muscular tissues, but also in the blood, lymph, chyle, pancreatic fluid, milk, saliva, fat, and other secreted substances. These globules, then, may perhaps be regarded as the final molecules of which organic bodies are com-

posed; and they are certainly quite distinct from any thing to be found in such as are inorganic.

But if the structure and physical characters of inorganic and organic substances are thus dissimilar, a still greater difference is observable in the actions of each, and in their relations to the external world. Thus the motions of inorganic substances, and of their integrant particles, are subject to certain chemical and mechanical laws alone, which, as uniform in their operation, may be easily determined by experiment; whereas, the motions of such as are organic, and of their integrant particles—the reciprocal conversion of the one into the other—the interchange of their particles with those of other substances, &c—are regulated by laws quite distinct from such as are simply chemical and mechanical,—laws apparently much less uniform in their operation, and certainly much less easily ascertained, and less confidently to be calculated upon. It is in the sum of these and other similar motions, that *life* consists; which is, accordingly, the distinctive attribute of organic matter, vegetable as well as animal. The peculiar phenomena of life, or those motions which take place in organic matters, and to which such as are inorganic present nothing similar, are principally those by which they effect, for a time, incessant changes in their own composition, exerting, at the same time, a reciprocal action with the substances of the external world; those by which they resist, for a time, the deleterious action of external agents;

those by which they perpetuate their species; and those by which they are at length overtaken by death, and reduced to the state again of mere mineral matter.

With respect to the first series of actions, all organic substances possess the power of taking from the external world certain solid and liquid matters, which they assimilate to their own nature, and thus repair the waste which they are continually undergoing; and it is to this renewal of their blood from without that *digestion* is instrumental. Further, they have the power of effecting a motion of this blood between the interstices of their solid parts, constituting the function of *circulation;* the ultimate object of which is, the continual conversion of a portion of this blood into the several tissues and secreted fluids, and reciprocally the continual reconversion of these tissues, as well as of such of the fluids which are not evacuated from the body, into blood,—in which motions consist the functions respectively of *nutrition* and *secretion*, and of *absorption*. Lastly, they have the power of taking from the external world certain æriform, as well as solid and liquid substances, while they give off others, for the purification of their blood, vitiated as it is by the processes just mentioned; and it is to this interchange that *respiration* conduces.

These continual revolutions are so characteristic of organized beings, that by some life is described as essentially consisting in them: "La

vie," says Cuvier, "est donc un tourbillon, plus ou moins rapide—plus ou moins complique,"—but nothing similar is met with in minerals. These increase merely by the accidental addition of new particles to the original mass; they display no motion of fluids along solids—no molecular interchanges of the two—nor have they any action with the external world, except such as is strictly either chemical or mechanical.

In the second place, organic substances are capable, so long as the changes just alluded to are going on, of resisting and modifying the action of heat and cold, of moisture, and of chemical agents in general, to a most remarkable degree; and this property of self-preservation is in them so striking, as to have been regarded, from a very early period, to be the most essential attribute of life. It is well known that plants in general are commonly above the temperature of the surrounding medium, if that be low, and inferior to it, if it be high—nay, that some of them vegetate in perfection in water, the temperature of which is sufficient to have boiled them, had they been deprived of life,—and this property of resisting cold and heat is still more remarkable in animals. The living egg is generally above the temperature of the atmosphere, and it is frozen with great difficulty; and the power possessed by the higher classes of animals, and particularly by man, of preserving a more or less uniform temperature, under extremes of cold and heat, is almost unlimited. In very cold climates, the thermometer

not unfrequently sinks to 50 or 55 degrees below zero, while in very hot ones it is sometimes 120 or 125 degrees above it—making a difference of 170 or 180 degrees; and still the temperature of the human body remains almost unchanged; and with respect to artificial heat, it has been proved that man can bear with impunity, for a considerable time, a degree of heat which would have roasted him in a few minutes had life been extinct. So also the combination with heat of moisture, so prompt in effecting the decomposition of vegetable and animal substances, when life has deserted them, is quite inert in this respect while life continues; and the same is the case with certain chemical agents, commonly reckoned among the most active, with respect to inorganic substances, but which are quite impotent with respect to such as are organic. Of this nature is the substance called the gastric juice, contained in the stomach of animals; which has no effect upon any thing living, but rapidly acts upon almost any vegetable or animal substances, once divested of life. Thus seeds are uninjured in their passage through the stomach and intestines of animals, so long as they retain their life; worms and other animals are capable of living, for an indefinite time, in the stomach as well as in the intestines; and a living leech, if accidentally swallowed, is never acted upon till life is extinct, when it is rapidly digested, like any other animal matter;—nay, the coats of the stomach itself are not unfrequently found to have been

corroded after death, by the same fluid, which is essential, during life, to its natural and healthy function. Now, inorganic substances, on the contrary, are acted on by heat, or the abstraction of it, by moisture and by chemical agents in general, in a uniform manner, and to a uniform degree; while over organic bodies they exercise no controlling influence whatever.

Again, it seems to be a universal law, that living beings alone can give origin to other living beings, either by a partial division of themselves, or by a peculiar process called *generation*;—whereas the origin of inorganic substances is always quite independent of any pre-existing substance of a similar kind.

Finally, the actions of organic substances having attained their acme of intensity, gradually decay, and at length, from causes which are inherent in each individual, cease altogether, when the substance becomes at once amenable to the operations of merely chemical and mechanical agents. Such is not the case, however, with inorganic substances, which maintain the same state unalterably, and for any length of time, provided no external agents are brought to operate upon them.

Such, then, are the principal distinctions between inorganic and organic substances, with respect both to their structure and motions, and such the principal phenomena which living beings display. The question then arises,—Do these

distinctions depend upon the possession by the latter of any substantial principle of action, of which the former are destitute; or do they depend merely upon some peculiarities in the properties of those matters, of which inorganic and organic substances are respectively composed?

The term *life* has been commonly used with the utmost vagueness, and any attempt to explain its nature has been in general regarded hopeless in the extreme. The authors who have written on the nature of life may be arranged into two great classes—the one comprehending those who consider it a subtle substance—a real and distinct agent—attached to certain forms of matter, and the *cause* of the remarkable phenomena which these display; the other comprehending those who regard it as merely a certain mode of being, *consisting in* these associated phenomena, and the result of certain combinations of matter placed under peculiar circumstances.

This subject may perhaps be beyond the legitimate bounds of philosophical enquiry, and at all events it is not necessary for my present purpose to enter into a speculation so dark, and possibly so dangerous. A distinctive attribute of life, at least as displayed by the higher order of living beings, is *thought;* and it is difficult, if not impossible, to conceive that this can be, either directly or indirectly a property of matter: and if we are thus compelled to assign to the higher attributes of life, an essence distinct from that of matter, we appear hardly justified in assuming

that its lower attributes are independent of a similar principle of action; but we know nothing of the essence either of matter or mind; all we know is, that each exhibits phenomena totally distinct from the other, and possessing, so far as we can perceive, nothing in common. The one is extended, figured, divisible—hard or soft—solid or fluid—the other does not display any of these qualities, but feels, and thinks, and reasons.—That the mental phenomena do not exist in this sublunary state, except in connection with organized bodies is undeniable; but were we to go farther, and attempt to penetrate into the nature of that connection, we should soon find ourselves involved in speculations beyond the reach of the human faculties. Were we inclined, for example, to assume that mind is a mere result of material organization, we might find many plausibilities by which the theory could be maintained, arising from the peculiar developements of the one, as connected with the greater or less degree of perfection exhibited by the other, and there is assuredly something attractive in the views which might thus be opened up to us; but we must not forget that there is something within us which is to survive our organic structure, and that the one infinite Mind from which the universe proceeds, cannot, without absurdity, be supposed to be inherent in a material frame; and here I am contented to stop, with the humble confession, that "such knowledge is too wonderful for me—it is high, I cannot attain unto it."

It is enough for us to know that in the material world there are adaptations which connect it in the most wonderful manner with the mental, and that in no respect is this so strikingly exhibited as in the organization of living bodies. This adaptation, on whatever laws it may depend, is an undoubted and a most interesting proof of the wisdom and goodness of the great Author of Nature. Had the case been in any instance reversed—had the imperfect organization of an oyster or a worm, for instance, been connected with mental faculties and aspirations, such as those which belong to man, how miserable would be the condition of that being, and what an argument might have been founded on it against the existence of an intelligent and beneficent first Cause. But it does appear no slight indication of a Divine hand, that the relation between the properties of organized bodies and their living faculties should be so intimate and so uniform—that is, that the lowest state of the one should be so constantly associated in animal life with the lowest state of the other, while the more perfect developement of organization is always attended with such a proportional developement of the living power as to originate, and plausibly to support, a theory formed on the assumption that the one is the necessary result of the other. The gradation of organized substances is indeed one of the most beautiful and delightful manifestations of the order and harmony which subsist in the relations of earthly things. By what

insensible steps do we pass from mineral substances to the lowest tribes of vegetables and animals, and from these again to the highest tribes of both, till, following the latter in the ascending scale, we arrive at immortal man! Thus, among vegetables, how gradual is the ascent through the humble acotyledonous plants—the algæ, fungi, lichens, hepaticæ and musci—to the filices and other monocotyledonous orders, and through these again, to the dicotyledonous, till we reach the most stately of these; and, among animals, how imperceptible is our progress through the invertebral animals—the zoophytes, worms and insects, on the one hand, and the vertebral animals—the fishes, reptiles, birds and mammalia, on the other, till we finish with the most exalted example of animated nature!

> "Each moss,
> Each shell, each crawling insect holds a rank,
> Important in the plan of Him who framed
> This scale of beings—holds a rank, which lost
> Would break the chain, and leave behind a gap
> Which Nature's self would rue."

It is undoubtedly a pleasant and instructive task to follow these relations, and to trace the manner in which they act and react on each other, and there does not appear to be any good reason why they may not be considered in the light of cause and effect, in the only truly philosophical sense of these terms—implying an uniform and invariable sequence. But I do trust

my readers will never forget that, in the employment of such language, a reference ought constantly to be understood to a *primary* designing Cause—that eternal Being who has not only at first impressed laws on nature which indicate his infinite perfection; but, of whom it may in every instance be truly said, that these laws are no other than the modes in which his Divine power is exercised.

A distinguishing mark of an organic substance, in as far as its structure is concerned, is, as the name implies, the possession of certain *organs*, each of which is more or less essential, as I have already remarked, to the welfare of the whole; and an equally distinguishing mark of the same substance, as far as regards its motions, is the performance by these organs, each of its own proper *function*, in the sum of which the life of the being appears to consist; it seems proper, therefore, before dismissing the subject of life and living beings, to say a few words first of these organs—at least as they present themselves in animals in their general relations to each other; and afterwards of the functions performed, and the general co-operation of each to the perfection of all. It is not my intention to allude, in this place, to the admirable adaptation in every animal, of the structure of each of its organs to the functions which this is destined to perform, since this beautiful subject will be found considered at some length in another part of this work—at

present my object is to compare, not organs with functions, but first organs with organs, in order to trace the analogies, as well between the different organs of each animal, as between the corresponding organs of different animals; and subsequently functions with functions, in order to trace their mutual dependence on each other.

I have elsewhere remarked that it is by a union of more or fewer of the tissues, composing an organized being, that its several organs are formed; and the power by which this union of the tissues, or organization, is effected, has been long known by such various names as *Vis Plastica*, *Nisus Formativus*, &c. So far, however, giving a name to this power is equivalent only to admitting its existence, and tells us nothing whatever, either of its nature, or the laws by which it operates. It is, in the language of Hamlet, merely "words, words, words!" but some modern Physiologists have endeavoured to push the matter beyond mere words, and to discover and demonstrate some definite laws, by which organic elements, or tissues, are combined to form organs—many of which may be essentially the same in their organic structure, however various their form and functions—in the same way as the particles of crystals are combined to form salts, several of which have one common primary character, however different their aspect and properties. This idea seems to have originated—in so far at least as it is a modern one—in Germany, and has been prosecuted principally

in that country, and in France. It seems to have been entertained first with respect to the several bones comprising the skeleton of the vertebral animals. It was observed that all the essential parts comprising a vertebra, or one of the bones of the spine—its body, processes and canals—were to be found in the posterior bone of the skull, that the same presented themselves again in the bones forming the central parts of the skull, and a third time in those of which its anterior part was composed; the skull, therefore, was considered to consist essentially of three vertebræ, however dissimilar it might be in its general aspect. And it is only in man and the higher tribes of animals that even this dissimilarity is striking:—in the lowest family of fishes the vertebræ and bones of the skull are, not only essentially, but very obviously analogous to each other; and the transition from these through reptiles, birds, and quadrupeds, up to man, is, with respect to these bones, so gradual, that any analogy which we admit in the first case must be extended to the last also. There was thus then a kind of unity of organic structure established between parts at first view very different from each other; and the same idea of a unity of organization was subsequently extended to all the other bones, the prototype, as it were, of every one in the body being met with in either a vertebra or a rib. Thus the bones comprising the upper jaw were discovered to be nothing more than the transverse processes of some of

the vertebræ of the spine, while the lower jaw was represented as merely a repetition of a rib. So also were the collar-bone and the blade-bone, on the one hand, and the several bones composing the pelvis, on the other. Again, the bones of the upper limbs were found to be formed on the same model as those of the upper jaw, and to be analagous therefore to transverse processes of vertebræ; while those of the lower limbs were described as cast in the same moulds as the lower jaw, and analagous therefore to a rib. All this is apparently very far fetched, and almost ludicrous, when we look at man alone; but it is feasible enough in its application to some of the lower tribes of animals, the rise from which to man is so gradual, that each step is almost imperceptible. Now, if these analogies be admitted, it is obvious that, in the process of organization, the granules, of which the osseous tissue consists, must coalesce so as to form, in every case, kinds of nuclei, of which there are but few primary forms, however various may be those of the bones built upon them. Nor has this doctrine been confined to the bones,—it has been extended to all the soft parts of the body. The organs, soft as well as hard, on one side of the bodies of all animals, with very few exceptions, are certainly repetitions of those on the other:—there must be some fixed laws to determine this obvious instance of unity of organization; and the same laws are presumed to be in operation in numerous other instances,

which, as less obvious, have attracted less general attention. Accordingly, by the observations, or, as it may perhaps be thought, by the ingenuity of some recent Naturalists, an analogy, more or less strict, has been detected between several soft organs, which have at first view no manner of resemblance, but which, nevertheless, are presumed to be only rough copies of each other, both being formed, as it were, upon the same nucleus, and differing only in certain almost accidental particulars. In this view of the matter almost every organ in the upper part of the body is presumed to have its fellow among those of the lower, and almost every organ on the anterior part, its fellow among those of the posterior.

Undoubtedly there may be something, at first view, very forced and fanciful in these speculations; and the science of unity of organization, if there really be matter for any such science—that is to say, if there really exist any discoverable laws which regulate the formation of these organs—is, it must be acknowledged, still in its infancy. That there must exist such laws is unquestionable—the only question is, whether they are such as philosophy can find out; and perhaps we have no more right to deny at present that it may do so, than we should have had some few years ago to deny that the definite proportions, in which elementary bodies unite chemically to form compounds, could ever be ascertained. The atomic doctrine in chemistry was, only a very short time since, in as little repute

with the generality of mankind as the science of unity of organic structure is at present; and what has not the former doctrine, assiduously prosecuted, done for chemistry? It has converted it, from a vague and unsatisfactory statement of isolated facts, into a certain, a consistent, and a determinate science; and why may we not hope, that the prosecution of the study in question may do as much for anatomy, and teach us not to be satisfied with knowing merely what *is* the structure of each organ, unless we can explain also *why* it has that structure, and why it could not, consistently with certain established laws, have had any other?

> " All nature is but art unknown to thee;
> All chance, direction which thou canst not see."

It is only, however, as I have already observed, when we take a full survey of the whole of animated nature, and observe the strict analogies between certain organs in each of the various tribes of animals, as we rise progressively in the scale of creation to man, that we are struck with the analogies which these same organs, as occuring in the human body, also offer. No two things, for instance, seem to be more unlike than one of the vertebræ and the posterior bone of the skull in the human skeleton; but in some fishes they are nearly entirely the same, and the gradations in both, from a fish to man, are almost insensible. So also the similarity between the ribs and either the lower jaw, on the one

band, or the collar-bone and blade-bone, or the bones of the pelvis, on the other, is very obscure in man, but very obvious in many of the lower animals, as fishes and birds; and, that between the lower jaw and legs, which in man is exceedingly difficult to be detected, is perfectly obvious in some invertebral animals, as the crayfish. Let us pause, then, before we deny that the reputed analogies, which have been pointed out between the several organs of the human body, have any existence; or, that the science which investigates the laws which regulate these analogies, is susceptible of any useful application.

But such analogy—such unity of organization is much more striking, when we come to compare certain organs of one animal with the corresponding organs of another; the conviction being now almost forced upon us, that the vis plastica really operates according to certain fixed rules, from which it does not, in any case, recede. One of the best examples of this kind of analogy is that which subsists in a certain class of organs, as found in two individuals of the same species, but of different sexes—an analogy which seems to have been noticed first by Aristotle, and to have impressed upon him the first idea, which was ever entertained, of a general unity of organic structure. I am unwilling to prosecute this subject at present; but I may be permitted to observe, before leaving it, that, in the embryo of most animals, the organs above alluded to are almost entirely the same, whichever is to be its

future sex, and that at every period of life, there is not, in either, any organ which is not obviously repeated in the other—however apparently useless it may be in one of them—as if nature, in conformity to a certain law, could not avoid constructing both after the same model. And, with respect to the analogies between certain organs of the human body and the corresponding organs of the inferior tribes of animals, these are so obvious, when we compare, for example, the arm of a man with the fore-leg of a quadruped, the wing of a bird, the anterior extremity of a reptile, or the thoracic fin of a fish—in all their parts, soft as well as hard—that nobody can refuse to assent to them. So far, a degree of unity of organization is, and must be, universally admitted; and, if we take almost any other organ of man and the superior animals, it would not be difficult to trace its prototype in some corresponding organ in the very lowest tribes. Thus man and quadrupeds—birds and reptiles—have lungs but no gills; while fishes, on the contrary, have gills but no lungs: but all the former had, at an early period of their developement, gills and no lungs; and the lungs, which even man at length acquires, are easily traced through the fleshy lungs of birds, and the membranous lungs of reptiles—of serpents in particular—to the air-bladder of fishes, as their prototype. Again, the mammalia and birds have a double heart, and but few large blood vessels immediately connected with it;

while reptiles and fishes, on the contrary, have a single heart, with which numerous large arched vessels are directly continuous; but man himself —and, *a fortiori*, quadrupeds and birds—had at one stage of developement, as single a heart, and as many arched vessels connected with it, as the most insignificant reptile or fish, which still furnishes them with their model. Further, man has a highly complicated brain, while the lower animals, on the contrary, have a brain more and more simple, the farther they are from the perfection of his organization; but the nucleus, as it were, of the brain of man and of that of a fish, is still found to have been cast in the same mould. What then is man, with his fins, and his gills, and his air-bladder, his single heart and branchial arches, and his undeveloped brain, but a kind of fish—better appointed indeed—but still truly and fundamentally, as far as the essential structure of his organs is concerned, a kind of fish—nay, what is a fish, in all probability, but a better appointed zoophyte—so that man, proud man, has, in the distinctness and splendour of his organization, really nothing but what a polype has in confusion and obscurity! The invisible germs of all animals are perhaps essentially the same; and even the visible embryos of the most opposite tribes are often quite indistinguishable from each other. The foundation stones of all, if we may so express it, are of the self-same number and form; and upon each of these is reared a superstructure, always

of the same character, but higher or lower, according to the rank which each individual being is to hold in the scale of creation. To each has the Creator said, "Thus far shalt thou go, and no farther." Of some the progress has been very soon arrested; to others a greater advancement has been allowed; while, in man, to so towering a height has he been permitted to proceed, that he is tempted to deny his affinity with the others, and to lose sight of the humble beginnings on which all equally rest. But why should man, in his arrogance, claim to himself a nature and essential organization different from those of even the lowest animated being? The same Divine hand, which has permitted him to build so much higher than they upon the same foundation, might have permitted—perhaps has permitted—other beings to proceed infinitely farther still; so that to them, man is far, far more insignificant and contemptible, than to him is the veriest worm that crawls. May this view tend to inspire us at once with humility and gratitude—with humility, in reflecting on the grovelling nature to which we are so intimately allied; and with gratitude, in contemplating as well the comparative superiority which we have been allowed to attain, even in this state of our existence, as the Divine promise, which has in mercy been extended to us, of a more exalted and better condition in the world to come.

It remains still to say a few words concerning

the several functions performed by organized beings, and of the relations in which these stand to each other. I have already alluded, while speaking of the characteristic actions of animals, to those by which they renew their blood, by assimilating to their own nature solid and liquid substances received from without; those by which they circulate this blood; those by which they deposite from the blood the various tissues and secreted fluids, in proportion as they have been removed; those by which they receive again into the blood such tissues and fluids as have become useless; those by which they purify the blood, as it becomes deteriorated in these processes, by the reciprocal expulsion from it, and reception into it, of certain aeriform matters; and lastly, those by which they renew their species. These include, as I remarked, the functions of digestion, circulation, nutrition and secretion, absorption, respiration and generation.

A *function* may be defined to be the proper action of a living organ, or set of living organs, conducive to some definite end in the animal economy. It is therefore quite distinct from a *property*, such as that of excitability, or a *power*, such as those which call excitability into action; since it signifies such properties and powers in mutual co-operation. Every action of every individual organ of the animal body is its function, and the due performance of this is the only end of its existence; but the functions, collectively

considered, are commonly classified according to the particular end to which more or fewer of these actions are subservient, since they would otherwise be altogether innumerable, and the consideration of them would involve a series of useless repetitions, and present an inextricable chaos, without beginning or end. In this view, therefore, we include, under the head of the function of digestion, all the actions of the several parts of the intestinal canal and its appendages, which are instrumental to the assimilation of the food; under that of the function of circulation, all the actions of the heart, blood vessels, and other parts, which are subservient to the propulsion of the blood; and, under that of the function of respiration, all the actions of the chest and its contents, which minister to the conversion of venous into arterial blood, and many other important ends. It is obvious, therefore, that the number of the functions admitted into any treatise on physiology is almost entirely arbitrary—each of those just mentioned including perhaps twenty distinct functions of twenty different parts; any one of which might have been selected, if we had been so pleased, and treated of as a separate function. But, if the enumeration of the several functions be so indefinite, their arrangement is hardly less so; and accordingly, not only very different heads of functions, but very different arrangements of these heads are to be met with in different authors. By the Father of Medicine the sum of the functions of

the living body were aptly compared to a circle, in describing which we may begin at any point, and set off in any direction we choose ; and there is certainly no point at which we can begin, but it requires a great deal of previous knowledge to render it at all intelligible, and none which can be in any degree exhausted, without involving more or less, the consideration of almost every other function of the body. One leading ground of distinction, however, between the functions is, that while some of them require only *excitability* in general to be called into action, and are carried on without the consciousness of the individual, and not only independently of the will, but even against the will, others require some new properties superadded to general excitability, such as *sensibility* and *susceptibility of thought*, and are not only attended with consciousness, but subject, in a great measure, to the control of the will. The former of these have been called collectively the *organic functions*, since they are common, under some modification or other, to all forms of organized beings—vegetable as well as animal—and include all those to which I have already alluded ; the latter have been called *animal functions*, since they have been presumed to be characteristic of animals, and include sensation, thought, and voluntary motion.

Such then, is the ordinary general arrangement of the functions of animals, founded on presumed differences in their essential conditions, the former class requiring, for their display, only

a general property common to all living matter, the latter, some specific properties in addition; but there is another, and perhaps a better foundation for such an arrangement, in certain general ends to which more or fewer of the several functions—independently of the individual end to which each is subservient—conjointly conduce. These general ends are three; the ultimate object of every function being either to preserve the individual in a state of life and health, to perpetuate its species, or to maintain its relation with the external world; and in this view of the matter the functions have been arranged into the *nutritive*, the *reproductive* and the *relative*. Of these, the first head includes digestion, circulation, nutrition and secretion, absorption and respiration, all of which extend no further than the individual, and have no ulterior end; the second includes generation alone, and is exercised for the sake, not of the individual, but of the race; and the third includes sensation, thought and voluntary motion, and furnishes us with the only means which we have of maintaining an intercourse with each other, with nature, and with nature's God. It will be observed that this arrangement does not differ very materially from the preceeding—in fact, it leads to the same order of succession in classifying the functions, but, as founded on less questionable principles, and leading to a more precise nomenclature, it appears to be infinitely preferable to it. Further, it is the one best

adapted continually to inculcate upon the mind the main purposes of our existence, as living and rational creatures; and to lead us to observe, while investigating the phenomena of each function, the admirable adaptation of the means to the object, not only individual, but general, for which this function was appointed, and to which, in common with others, it conduces, as subservient, directly or indirectly, to the great end of our being.

CHAPTER III.

RELATIONS BETWEEN EXTERNAL NATURE AND THE PHYSICAL CONSTITUTION OF MAN.

In the examination of nature in her details, we shall find innumerable instances of the adaptations of *means* to *ends*, in matters so small, and for purposes, minute indeed, but of such vital importance, as are calculated to draw forth our highest wonder and admiration ; but without at this time entering on these, I shall content myself with making a few observations on the more general adaptations of the external world to the constitution of man—the central point, as it were, of corporeal existence, to which all others are subordinate.

And, first, the size of the objects around him is calculated to harmonize with the medium size of man. Had his body been much less than the average size, or considerably larger, both extremes would have been equally unfitting for the due exercise of the physical faculties.

We have many fables of giants of prodigious strength and altitude, but supposing such to exist, it is highly probable that their bulk and weight, in relation to our present laws of gravity, would render them perfectly unwieldy and helpless.—

No part of the natural history of man has been so disgraced by hyperbolical exaggeration as this —no authenticated instance being on record of a man higher than eight or nine feet; and, even among the numerous instances of this kind, most seem to have been the effects of disease; indeed it is a general observation that very large men are seldom distinguished by force or extent of mental power. The size and dimensions of the human figure, notwithstanding the fables of antiquity, appear to have been much the same in all ages of the world. That giants did formerly exist, is said by some to be proved by the testimony of the Bible—the book of truth—the holy word of God. But by the Hebrew words *nephilim*, *gibborum*, *enachim*, *rephayim*, *emim* and *zumzuzim*, which occur in Genesis, and which in all versions have been rendered by the term "giants," are probably meant in general, persons of great knowledge, strength and courage, and also wicked, savage and cruel men—these words having no relation to men of gigantic stature.

Og, king of Bashan, and Goliath, who is said in the Book of Samuel to have been six cubits and a palm high, have also been brought forward on this subject. But the latter text may be easily explained; for it has been calculated that six cubits and a palm is equal to about nine of our feet. If that be the case, by deducting the height of the helmet which Goliath wore, we shall find him to have been about eight feet high, and con-

sequently not surpassing in height some men in modern days. I moreover may observe, that some writers, upon other calculations, assign to Goliath but seven feet.

With regard to Og, the passage which concerns him is still less conclusive; indeed the text merely says that the dimensions of Og's bed were nine cubits long and four wide; and we know that one of the greatest proofs of riches, and a necessary concomitant of pomp and parade among the Orientals, was a large and magnificently ornamented bed, without any relation to the size of him who occupied it.

With respect to profane authority also, it was the custom of the ancients to exhibit in the same sculpture in bass relief, men of very different dimensions—making kings and conquerors gigantic, while their subjects and vassals were represented as only a fourth or fifth part of their size. This must have given origin, among them, to the fables of giants and pigmies; while a belief in such tales has been supported by the discovery of gigantic bones, which, through ignorance, have been received as human remains. Such bones are now, however, well known not to have belonged to man, but to extinct species of animals, of the elephant and other allied kinds, or whales; thus, it is not long since the bones of the fore fin of a whale were publicly shewn as those of a giant's hand.

The same explanation applies to those pretended skeletons of giants of twelve, twenty, and

thirty cubits high, mentioned by Philostratus and other ancient writers; as, for example, the skeleton of forty-six cubits, which, according to Pliny, was found in the cavity of a mountain in Crete, upon its overthrow by an earthquake; the skeleton, sixty cubits high, which Strabo says was found near Tangis in Mauritania, and supposed to be that of Antæus; the skeleton of Asterias, son of Anastes—ten cubits; and also that of Orestes, seven cubits, dug up by special command of the oracle.

Against all these alleged proofs, however, of the existence in former times of giants, it is sufficient shortly to observe, that the Egyptian mummies of three thousand years' standing, exhibit no difference in stature from men of the present day; that most of the ancient sarcophagi which have been preserved, are of the ordinary size of modern coffins; and, that we read that the Emperor Augustus was considered by the Romans as a person of middle stature, and his height is recorded to have been five feet nine inches of our measure.

The testimony also of some modern authors on this subject is altogether vague and unworthy of credit. Demaillet speaks of a giant whose hand was four feet long; and a celebrated traveller tells us that the guards at the gates of the city of Pekin are fifteen feet in height! but a being of this height, and muscular in proportion, would require a world of density different from ours before his strength could be available, and it is very

doubtful whether such a bulk is, under any circumstances, compatible with the agility, the delicacy of touch, and various other physical properties of man.

But suppose such a being as is here spoken of to exist, and all things around to remain as at present, how helpless and pitiable a mortal he would be! The tallest trees would be to him but as shrubs; the grass and herbs as microscopic plants; the few bullocks in a country would scarcely suffice him for a season; and, all other animals of less size would be to him insignificant.

Suppose, on the other hand, man was of pigmy stature—a few inches only in height, how limited would be his efforts; how narrowed and circumscribed would even the greatest intellects be with such deficient physical powers. A small brook would be to him an impassable barrier; rivers and seas would interrupt for ever the tide of commerce and the spread of knowledge; wild beasts would be dreaded as the greatest terrors; and, in every insignificant animal he would find a formidable foe.

That dwarfs occasionally exist there is no doubt; but their existence is always to be regarded as a monstrosity. Such was the case with the celebrated Jeffrey Hudson, the dwarf of the Queen of Charles the First, who, when an adult, was only eighteen inches high, and was served up to table in a cold pie! as also with the dwarf named Lolkes, who was exhibited at

Astley's Amphitheatre at London in 1790, and whose height did not exceed twenty-seven inches. But it is needless to proceed farther with this subject; the average size of man has probably been in all ages, and in all countries, nearly the same as at present; and it is to this size of man that the size of all the objects which surround him seems to be best adapted. The admirable fable of Gulliver at Lilliput, where he was a giant, and at Brobdignag, where he was a pigmy, beautifully illustrates the inconvenience and dangers which would have encompassed man on all sides, had his relative size been different from what it is.

Then, as to the other circumstances of external nature; what is there even of her humblest arrangements that we could omit or modify? The air which surrounds us is, in its chemical properties, precisely that which is adapted to support respiration; and, in its mechanical properties, precisely that which is calculated, by its pressure, to preserve the body in health and vigour. If, instead of the two principles called oxygen and nitrogen in certain definite proportions, it had consisted of any other ingredients, or even of these two in any other proportions, death would in a short time have ensued—had the oxygen been in excess, from the stimulus which it imparts being so violent as to produce inflammation; and, had the nitrogen been superabundant, from the inadequate supply of that principle, on which the purification of the blood

essentially depends. Again, had the density of the air been much greater or less than it is, the energies of man would have been, on the one hand, oppressed by it, as by an unnatural load, and on the other, insufficiently sustained by it, as by a defective support. We all feel more or less of these effects on every sudden change in the barometrical pressure, and, still more remarkably, on either descending below the water in a diving-bell, when the air becomes preternaturally dense, or ascending into the atmosphere in an air-balloon, when it becomes preternaturally rare; and had either of these states been permanent, its effects on the human economy must have been most prejudicial. Among other things, the senses of both smell and hearing, both which depend for their perfection on a medium density of the air, would have been either insupportably intense or defective. Further, with regard to light—the first of created things, and the creation of which is described in the most sublime passages of written language—this is precisely such as is adapted, when reflected from the objects which surround us, to afford the proper stimulus to the organ of vision; and, even the colours of the most common objects are those which are most refreshing to the sense of sight.

The blue sky which surrounds us, could we, with advantage, change in colour? This colour, which is owing to the thin watery vapours floating in the atmosphere, and reflecting peculiar rays of lights—the blue and the violet, might

appear at first sight as a matter of chance—the mere cast of a die. But suppose any other had been reflected—a bright yellow or dazzling white—a glaring red—a fearful copper colour; or, suppose no reflection had taken place at all, but a black dome had surrounded the whole earth, and light had only become manifest when the eye received it directly from the sun—how uncomfortable such arrangements would have been for the vision of man! Of all the hues we could imagine, is there any to surpass that mild and soft etherial tint, harmonizing with all around us, and on which the eye, fatigued with more brilliant and dazzling objects, turns for relief and repose?

It is the same with the green livery of the earth. A single fiat of the Creator might have made plants and herbs reflect any of the other colours; but what other colours could we substitute in preference? It is remarkable, that even in the art of the painter, blue is a transparent colour, and green an opaque; both are subdued colours, but green would not have suited the sky; and blue, even if we could divest ourselves of all previous associations, would have been a cold and dismal garb for the groves and plains.

Next, with respect to the succession of the seasons; some theorists, fancying they could have produced a better arrangement of things, have objected to the obliquity of the earth's axis, in relation to the plane of its orbit round the sun.

They have supposed that, if the axis had been perpendicular to the plane of the orbit, and the seasons had been thus uniform over all the earth, the disagreeable vicissitudes of temperature to which we are now exposed would have been prevented. But this obliquity serves important ends;—it tends to diffuse the influence of the sun's rays over a larger portion of the globe than could have taken place by any other arrangement, and in this way extends, in a considerable degree, the habitable surface of the earth. Had the earth's axis been perpendicular, our climate in Britain never could have been warmer than the weather is at the vernal equinox.

It is true, a much less degree of external heat than this might have answered fully the purpose of sustaining the natural temperature of man; for, by a beautiful provision of nature, he is capable of maintaining the heat of his body at very nearly the natural standard, under the most intense extremes of either cold or heat—as at Hudson's Bay, where the thermometer sometimes sinks to 50 degrees below zero, and at Pondicherry, where it sometimes rises to 115 degrees above it. But we must remember that, though man is thus a native of every climate, every other form of organized being—vegetable as well as animal—has its own particular habitat, and requires a certain definite temperature to bring it to perfection; and, as these are essential to the well-being of man, had the particular succession of seasons in which each of them thrives been

altered, his comforts would have been abridged, if, indeed, his existence had not been impossible.

But even the vicissitudes of the seasons have their charm, independently of their utility. There is a pleasing variety in the succession of spring, and summer, and autumn, and winter, exciting and keeping alive the perceptions of enjoyment in the beauties of nature, which a dull and uniform course, even of the finest weather, would ultimately fail to produce. It is highly probable, too, that the change of temperature continually taking place, influences the currents of the atmosphere, and tends to accumulate and diffuse the necessary moisture over every region.

I must not omit to notice, in connection with the subject of external heat, that the dark colour of the skin of man, in the countries where this is considerable, seems to be for the beneficent purpose of tempering its effects on his constitution. At first view it would appear that a dark skin would rather increase than diminish these effects, since dark colours absorb heat more readily than light ones; but we must remember that, though the extreme of heat is sometimes greater, as I have just observed, in these countries, than the heat of the human body, the average heat is generally considerably less, and dark colours, if they *absorb* heat, so they also *radiate* heat better than light ones; more heat is thus, under ordinary circumstances, given off from the body, owing to the darkness of its complexion, than is received into it. The average heat at Calcutta,

for example, is only about 76 degrees, while that of the human body is 98 degrees; and, as heat always tends towards an equilibrium, it is obvious that, as its general course, in this place, is from the body to the atmosphere, such a surface as favours its radiation will be a means of keeping the body comfortably cool.

And what, too, do we not owe to the irregularities of the earth's surface, the lofty mountains and the sloping vallies? Imagine the sameness, and the dullness, and the want of interest that would have accompanied a still and level flat, had it existed in place of the beautiful undulating valley, the abrupt and rocky precipice, the extended plain, the distant and majestic mountain. Had such a disposition been the case, whence would have come our constant and indispensible supply of spring water? The little rain that fell would speedily have found its way back to its mother ocean, leaving us little better off than the wanderer among the arid deserts of Arabia, unprovided for, and perishing from thirst and want of almost every kind. All the springs and wells in the world consist merely of rain water which has sunk into the bowels of the earth, again appearing, or gradually escaping, at lower places; and it is to the irregularity of the mountains, and to the porous and rocky caverns of the earth, that we are indebted for the facility with which water passes upwards and downwards through their various curvatures and levels. After wandering long, and filtering through soils

calculated to remove its impurities, it flows from out some aperture, a grateful and necessary gift to man, and, perhaps, gives rise to, or unites with other streams to form one grand majestic river, contributing with a liberal hand to spread along its course the beauty and fertility which adorn the surface of the earth.

Again, the proportionate abundance of vegetable and animal productions, respectively in hot and cold climates, is further in conformity with the necessities and comforts of man, as inhabiting such districts. It is well known that man thrives best in hot countries, on a great proportion of vegetable food; and here, accordingly, fruits and herbs of every description abound; whereas, in cold countries, the body requires more substantial and stimulating aliment, and it is here that flocks and herds are more prolific. Further, in the relative bulk of animals in respect to man, we find another wise provision in the adaptation of nature. Had animals been much larger, they would also have been more unmanageable, and had they been smaller, they would have proved but of little use; and here some curious speculations might present themselves, were we to consider the prodigious size of many of the antidiluvian animals, the remains of which have been preserved in the earth's strata. These seem to have been formed, and to have inhabited the earth before man had yet multiplied to people it; because, in the first place, among all these remains of animals no human

bones have been found; and, secondly, did there exist in the present day so many species of huge animals of carnivorous propensities, that power and command which the human race holds over the inferior creation might be disputed.

It is curious that skeletons of the hyæna, the hippopotamus, the rhinoceros, and the elephant, have been frequently discovered in Britain and in most parts of Europe, in countries and climates where no animals of these kinds were ever known in a living state, and in which the known species, inhabitants of the torrid zone, would be speedily destroyed; demonstrating that particular animals have existed in countries where they are now unknown; and, moreover, that certain animals have also lived on the earth's surface, belonging to species, and even to genera, entirely new to us. Of this description is the celebrated mammoth, a huge monster somewhat similar to the elephant, but specifically distinguishable both from that of Asia and Africa, discovered enveloped in an ice-berg in Siberia, in 1799.—The whole animal, as described by Mr. Adams in 1806, was in perfect preservation, with the flesh, skin, and long black hair, with which, unlike the elephants of tropical climates, it was covered. A very singular skeleton of an animal, now quite unknown to exist, was lately found in Germany, and another very extraordinary one, and of an immense size, was not long since dug from the alluvial soil of Buenos Ayres. It is almost appalling to contemplate the fearful convulsions

that must have taken place to annihilate so many species, but it is thus we see, that even the most tremendous catastrophes of our planet may have been active agents for bringing about the most important results.

In every thing, then,—in the relative size of the objects which surround us; in the character of our atmosphere; in the degree of light which pervades it, and, even in the prevailing colour of the most familiar objects; in the harmonious succession of the seasons, and the degree of heat to which we are exposed; in the supply every where of the most appropriate kinds of aliment; in the inequalities of the earth's surface, and, even in the obliteration of beings which would have been prejudicial to man—has the great Creator consulted the comfort and happiness of the human species; leaving nothing wanting to fill up our measure of gratitude to Him, who has so far exalted us above the other works of His hands.

CHAPTER IV.

STRUCTURE OF ANIMALS AS ADAPTED TO THEIR MODES OF LIFE.

Organs of Mastication, Digestion, Circulation of the Blood, and Respiration.

I HAVE already shortly alluded to some of the differences in the functions which animals perform; and, I now proceed, in this and the following chapter, to endeavour to show how admirably the several organs, engaged in the performance of these functions, are respectively adapted to the end in view. In a sketch of this nature, it is manifestly impossible to do more than call attention to a few of the most prominent features of the subject; but, from even one or two instances of obvious design, we may draw inferences as certain of the wisdom and the goodness of the great Creator, as from thousands; and hundreds of thousands would be inadequate to impress us, with more than a faint idea, of the stupendous extent to which this wisdom and this goodness are displayed in the animal creation.

In pointing out a few of the different relations of the structure and functions of animals to their

appointed modes of life, I shall begin with the zoophytes and worms of Linnæus, and then proceed, in order, through insects, fishes, reptiles, birds and mammiferous animals; making a few remarks, first, on the organs of each adapted to taking and chewing their food, and to digestion, the circulation of the blood, and respiration; afterwards passing on to those by which the several functions of smelling, seeing, hearing, tasting and touching are performed, and by which they are enabled to move from place to place.

In the simplest orders of animals, food is taken by mere imbibition, or suction, without any distinct organ specifically adapted to the purpose. They absorb their nutriment, sometimes without any evident aperture, and sometimes by several such apertures; and not unfrequently the intestinal canal—if it may be so called—of many individuals communicate together, so as to constitute, in fact, but a single animal. Such animals are really so closely allied, both in their appearance and functions, to vegetables, that the line of demarcation between them is not easily defined; and, fixed as they are, like plants to the soil, or other matters from which they immediately and constantly derive their nourishment, any other organs but those of mere imbibition, would have been superfluous to them. But all animals that are unattached to the substances from which they derive their aliment, and are

continually changing their situation, must possess distinct organs for seizing and preparing this aliment; and, hence the necessity in these, more or less constantly, for lips, in some one or other of their numerous modifications; for certain glands, placed about the mouth, to furnish a fluid by which the dry alimentary matters are lubricated; for a tongue, or some analogous organ; and, lastly, for jaws and teeth, by which such matters, when hard, are broken down, and reduced to a condition for swallowing. In quite the lowest orders, however, even of these, the mouth and stomach are almost one continuous cavity, the parts of which are indistinguishable from each other; but, as we advance a little in the scale, the parts become sufficiently obvious, and the office of each is clearly defined. Thus, among the Testacea, the snail has a very perfectly formed mouth, and, in front of it, regular lips, reflected so as to form a small canal within the mouth; while, in the wared whelk, the lips are elongated into a proboscis, adapted for suction, and capable of being retracted at the pleasure of the animal. Among the Mollusca, the cuttle has a circular fleshy lip, embracing a kind of beak, like that of a parrot; and the leech one fleshy lip, the orifice of which is triangular, and furnished with sharp edges—falsely called teeth—by which it is enabled to penetrate the skin of animals, preparatory to sucking their blood: its method of sucking is by dilating a large fleshy pouch, called a pharynx, at the back part of the

mouth, and thus forming a vacuum. Proper glands also, called salivary, for furnishing a lubricating fluid, are found in some of these, as the snail and cuttle, the latter of which has two distinct pairs, but they are not met with in the leech, for an obvious reason. With respect to the tongue, in the greater number of the lower tribes of animals, its place is supplied by palpi, or tentacula, placed around their mouth; but some, as the snail and the wared whelk, have this organ very distinct—the first on the floor of its mouth, and the second within its proboscis—and in both it is beset with prickles or hooks, apparently for retaining the food; the cuttle also has a tongue of a cartilaginous consistence, and with very little motion. A kind of horny upper jaw, likewise, with several teeth, is met with in the snail, while, in the cuttle, the place of both seems to be supplied by the horny beak already spoken of. The most perfectly formed jaw met with in this tribe of animals, is that of the sea-urchin, in which it constitutes a strong, bony frame-work, commonly known by the name of Aristotle's Lantern, surrounding the mouth, and consisting of five pieces, each containing a tooth, which is moved by muscles. Some of this tribe of animals have distinct teeth, without any proper jaws, as the star-fish and sea-anemone, in which they beset the orifice of the mouth, and the sea-mouse, where they are placed on the proboscis.

Of the apterous insects, the cray-fish has a

triangular mouth, as well as the leech, with a projecting fleshy upper lip, but no lower one; and somewhat similar are these parts in the spider. In the scorpion, on the contrary, and in insects in general, it is a long process of the lower lip which is usually called the tongue. In the buzz-fly, hornet-fly, gnat, mosquito, house-fly, &c., as well as in dipterous insects in general, the lips, like those of the wared whelk, are prolonged into a proboscis, containing a sucking-tube or tongue, and sometimes several penetrating points in addition. Insects are without proper salivary glands; but, somewhat analogous to these—although for a very different purpose—are the venom-bags of several tribes, as the centipede and the spider; in the latter of which there is placed upon the bag a hollow tooth, which, pressing upon the bag in the act of penetrating their prey, at once forces out a portion of the venom, and conducts it into the wound. All kinds of spiders appear to feed on animals alone, as upon other insects and very small birds, as the humming bird; and hence the advantage to them of this apparatus. The story of the bite of one kind of spider—the tarantula—producing in man a kind of St. Vitus' dance, which is curable only by music, is probably fabulous; but, that it occasions sometimes a very severe inflammation of the skin, is abundantly certain; and that of the centipede is not unfrequently fatal. It is upon precisely the same principle that many plants, as the common stinging-nettle, produce their

troublesome effects when applied to the human skin ; and the deadly venom of the rattle-snake, or cobra-da-capello, is collected and introduced into a wound in a similar manner. In the cray-fish, and insects in general, the place of a tongue is supplied by the tentacula which surround the mouth, what is commonly called their tongue, being only, as I have before remarked, a prolongation of the lower lip. In those insects, however, the lips of which are prolonged in the form of a proboscis, the tongue is a kind of sucking tube, contained within it ; while in the bee, the tongue is rolled into a sucking cylinder, within the elongated jaws. The structure of the jaws is in some insects very perfect, particularly in the cray-fish, in which they are divided into two mandibles, analogous to grinding teeth, and six pairs of proper jaws, moving from side to side, and not upwards and downwards, as in most other animals. Similar, in this respect, to the cray-fish is the scorpion and the spider ; while the beetle is intermediate, as it were, between these and the more perfect insects, which feed chiefly on juices, and take their food by suction. The larvæ of insects in general, however, or these animals in their rudimental state, are commonly furnished with very powerful jaws.

Of the vertebral animals, the lips of some fishes, as the sturgeon and the lamprey, are very similar to those of some worms ; and their sucking power is so great, that the lamprey may be

raised out of the water with a stone of ten or twelve pounds weight attached to them. Salivary glands appear to be altogether wanting in fishes, their office being abundantly supplied by the element in which these animals live; and some of them, as the flying-fish and the gar-pike, have no tongue; while others, as the common pike, a most voracious animal, the perch and the conger eel, have this organ extremely large. It seems in general but little adapted to tasting, being generally in fishes, as in the cuttle, of a cartilaginous consistence, as well as covered frequently with prickles, which have now assumed the appearance of regular teeth; it is supported on an osseous circle, a part of the branchial, or respiratory apparatus. The lower jaw, which alone in most fishes is moveable, consists, generally, of two lateral portions, only partially united together at the part corresponding to the chin; but in the lamprey it is consolidated into an immoveable ring, supporting the singular funnel-shaped lip already spoken of. In some fishes, as in the carp, the upper jaw is moveable as well as the lower; and when this is the case, there is a proper elastic ligament for raising, and a proper muscle for depressing it: the mouth is thus kept constantly open without any effort, whereas an effort is required for closing it; and how beautifully this structure is adapted to animals living in an element which furnishes them, for the most part spontaneously, with their prey, must be sufficiently apparent. The teeth of most

fishes are formed rather in the soft parts of the mouth, than in the jaws; but those of the rays and sharks agree with those of higher classes of animals in being formed in the jaws alone, which are furnished with several rows of them. They are in these animals of a triangular shape; but in the majority of fishes, more or less hooked; and in all they are calculated rather for lacerating and holding, than for chewing their food—a structure well adapted to the kind of food on which they subsist, and to the nature of their digestive process.

The lips of reptiles have nothing remarkable in their structure; and the frogs and turtles, for the same reason as fishes, are destitute of salivary glands. Many serpents, however, as the rattle-snake, and the cobra-da-capello, and some kinds of boa, have glands somewhat analogous to them, for the secretion of their venom, situated behind and below the orbits of their eyes, and compressed by proper muscles, so as to squeeze the venom through the hollow tusks which are placed in front of the upper jaw, and serve as ducts for the glands in question. A similar structure, as we have seen, is met with in some venomous insects, as the spider. With respect to the tongue of reptiles, it is short, and fixed to the floor of the mouth in frogs, salamanders and tortoises; while in serpents, on the contrary, it is exceedingly long and moveable, being enclosed, when retracted, in a proper sheath formed by the reflected membrane of the mouth; in most reptiles

also, the tongue is cloven at its extremity. The tongue of the chameleon, among lizards, is enormously long, of a cylindrical form, and susceptible of a kind of vermiform motion; and it is by this organ principally that the animal supplies itself with aliment, the insects on which it feeds becoming gradually collected on the long slimy tongue, as it hangs out of the mouth, and furnishing a full repast on the mere retraction of this organ. From this circumstance, in conjunction, probably, with the fact, that the chameleon can, by inflating its lungs, distend its body to an extraordinary degree, has originated the fable of its living on air. The jaws of reptiles, in general, are similar to those of most fishes; and in the venomous serpents, the upper jaw, like that of the carp, is moveable as well as the lower, apparently for the purpose of enabling the fangs to act with greater certainty. The teeth of reptiles also agree, for the most part, with those of fishes, being commonly pointed and hooked, and adapted, less for chewing, than for lacerating and retaining their food. All serpents have two rows of these in their palate; and, besides these, the harmless serpents have two rows in each jaw, while the venomous have only one row in the upper jaw, in addition to the two long fangs already spoken of; this circumstance furnishes one important means of distinguishing them.—Tortoises are destitute of proper teeth, their place being supplied by a rough horny plate, with which the jaws are covered, and which is

calculated for grinding, but not for lacerating their food. In every respect, then, the structure of these parts in reptiles is adapted to the particular habits of each tribe, and might almost have been anticipated, from a knowledge of these habits.

We come next to birds. This class of animals has neither lips nor teeth, the place of both being supplied by their horny bill, which, in some kinds, as the goose, duck, falcon, &c. is furnished with little tooth-like projections, for the purpose of assisting its actions. The salivary glands are much larger in the herbivorous than in the carnivarous birds; the food on which the former subsist requiring, apparently, more lubrication. The tongue of birds is of various characters; being in some, as the humming-bird, which takes its food by suction, tube-shaped, like that of the bee; in others, as the woodpecker, which transfixes its prey by this organ, cylindrical, like that of the chameleon; and in others, as the parrot, who uses the tongue only in the ordinary way, flat, like that of most mammiferous animals. Its consistence is sometimes cartilaginous, like that of fishes; and sometimes fleshy, like that of frogs. In the rapacious birds, it is often, like that of serpents, cloven; and in thrushes and starlings it is fringed at the point; it is very generally furnished with prickles, and in the toucan, it is even beset with feathers. The jaws of birds offer nothing remarkable, except that the

upper jaw, as well as the lower, is very commonly moveable, like that of the carp and the venomous serpents.

The lips of quadrupeds are, for the most part, less fleshy and prominent than those of man; and, in many of them, the upper lip has a fissure extending to the nose. As in birds, so also in quadrupeds, the herbivorous have larger salivary glands than the carnivorous; but these organs are quite wanting in the Cetacea, which, living constantly in water, have no more need of them than fishes, in which also, as we have already seen, they are wanting. The tongue of the cetaceous tribes, likewise, is more like that of fishes than quadrupeds, being almost of a cartilaginous consistence; whereas, that of the latter is in general soft and fleshy. It is usually flat; but in some, as the ant-eater, long and cylindrical, and thus well adapted to collecting the insects on which the animal subsists, almost in the same way as that of the chameleon. Some quadrupeds, as the cameleopard, use their tongue in the manner of a hand, in bringing down the young branches of trees, in cleaning out their nostrils, and so forth; and in these it is susceptible of a very great variety of motions. In the dromedary, and, still more remarkably, in the seal, the tongue is slightly cloven: it is fringed in the opossum, and, in most of the Feræ, beset with prickles, and sometimes even, as in one kind of bat, with scales. What is called the worm of the tongue in many carnivorous quadrupeds, particularly the

dog, is nothing more than a long elastic ligament under the tongue, corresponding to the lingual cartilage of some of the inferior classes.

The most remarkable feature in the lower jaw of quadrupeds is, the different character of the moveable joint in the herbivorous and carnivorous; in the former of which it is calculated to admit of motion chiefly from side to side, and in the latter, chiefly upwards and downwards; of the muscles which move it also, those which act in the lateral direction are strongest in the herbiverous quadrupeds, while those which act in the perpendicular direction are strongest in the carnivorous. If we observe the motions of the lower jaw, respectively in a sheep and in a dog, while engaged in chewing their food, we shall at once perceive these differences; and a knowledge of the anatomy of each directly displays to us how admirably the structure of the several parts is adapted to produce, on the one hand the grinding, and on the other, the crunching motion, which a herbivorous and carnivorous animal respectively requires. The general form of the lower jaw, likewise, differs very materially in the two; being much more elongated generally in the former than in the latter, to admit of the insertion of the numerous broad flat teeth which this grinding process demands. If the lower jaw of herbivorous and carnivorous quadrupeds differ so much from each other, the differences in the teeth of each are still more remarkable, and still more indica-

tive of design in their peculiar formation. Thus, while the front teeth of the former have uniformly broad cutting edges, which, meeting like the blades of a pair of pincers, are precisely adapted to nipping off the herbs on which they feed, the back teeth are, as I have just observed, equally adapted to grinding these herbs, and reducing them to a pulp, the copious flow of saliva in the mean time contributing to the same end. In carnivorous quadrupeds, on the contrary, both the front and back teeth are more or less pointed; and, while they are obviously incompetent either to bite off blades of grass or other herbs on which the graminivorous tribes subsist, or to grind them to a pulp if bitten off, are excellently calculated, the former to seize, and the latter, to rend and tear the flesh of other animals, which, being in general already more moist than herbs, requires a less copious admixture of saliva to reduce it to the requisite consistence.

We come next to the principal organs, which are subservient to the digestion of the food in the several tribes of animals.

By this process, the crude alimentary matters taken by the mouth, which are, in their original state, quite unfit to be received into the blood-vessels, undergo important changes, and are adapted to be converted ultimately into blood. The simplest form of digestive organs in animals, appears to be that by which alimentary matters, having been absorbed by the surface, undergo

the requisite changes equally in every point of the body, no specific apparatus being appropriated to the purpose. Such is the case with most of the zoophytes; and it is very remarkable, that many of those which present a purse-like appearance may be turned inside-out, without making any material difference in their powers of effecting these changes. They may be represented, if we please, as all stomach, or as having no stomach at all; for we may call the whole body stomach, if we will, but we must at the same time allow that they have no stomach, properly so called. Such an animal has been defined by Cuvier, a sentient self-moving sac, capable of digesting food. As we ascend, however, in the scale of animals, a specific organ becomes appropriated to every different function; and hence the necessity, in all but the very lowest classes, of a gullet for swallowing the food; of a stomach for retaining it, till it has undergone the first step of those changes to which it is to be subjected; of an intestinal canal for perfecting those changes, and for transmitting it so changed to the circulating vessels; and of a liver, and some other similar organs, for assisting, more or less essentially, in these operations. The simplest modification of a distinct digestive apparatus is to be met with, among the zoophytes, in the wheel-animal, in which there is a distinct membranous sac for the reception of the aliment; and a similar structure occurs in some kinds of sponge, in the sea-blubber, and in the sea-anemone. In the

sea-blubber, for example, there is, on the lower surface of the body, a simple aperture or mouth, leading by four passages into the same number of sacs or stomachs, which are not so much formed by a distinct membrane, as scooped out of the gelatinous substance of the body; they are, nevertheless, capable of digesting the small prickly fishes on which these animals subsist, as well as other substances apparently easily capable of resisting their action. But a more perfect modification of digestive apparatus is most common, not only in the higher classes of animals, but even in worms and insects. Thus, among the Crustacea, the sea-urchin has the gullet, stomach and intestinal canal quite distinct from each other; and this is still more obvious in some of the Testacea, as in one kind of snail, in which there is found besides a very large liver, a proper membrane, enclosing all these parts, as in the higher classes of animals, and called peritoneum. The same is the case, among the molluscous animals, in the cuttle, in which the gullet expands into a kind of craw or crop, similar to what is met with in some birds, and the stomach also is firm and fleshy like a gizzard. A similar crop and gizzard also are met with in some other animals of this tribe, as in the earth worm, in which the latter is often found to contain little pieces of earthy matter, which the animal seems to swallow—as some kinds of birds are known to do—for the purpose of assisting the attrition of the food. In so far they perform the office of

teeth ; and it is a beautiful illustration of the various means by which nature sometimes attains the same end, that to some similar animals, as the great marine worm, she has given actual teeth, situated in both the stomach and gullet, for this purpose. The stomach of the cuttle is furnished also with a spiral-shaped appendage, into which the bile is discharged from the liver. What is called the ink of the cuttle, generally, but erroneously, supposed to be the bile of the animal, and the chief ingredient, probably, in the common paint called Indian or China ink, is the product of a little pouch in the course of the intestinal canal, and of use in staining the water, and thus concealing the animal, when about to be preyed upon without any means of defence. With how obvious a design here, has nature compensated to the cuttle for the want of those prickles with which she has defended the surface of the sea-urchin !

The digestive apparatus of the leech is remarkable, principally, for a strong fleshy pharynx, or bag immediately behind the mouth, which, as I have already said, is its chief instrument in sucking the blood of other animals, and the long and capacious stomach, which is divided into several large cells, communicating with each other by oval apertures. It is through these that the blood is forced back again, when the voracious creature is made to regorge its disgusting meal.

In insects, the structure of the digestive apparatus is in general still more perfect than in the

preceding class. In the cray-fish the gullet is very short, expanding almost immediately into a large membranous stomach, which is situated above the liver, and distinguished by being supported externally by a very peculiar bony framework, consisting of five pieces, and by containing internally, three large and two small teeth, surrounding the orifice which leads to the intestines. These parts are regenerated, like the shell of the animal, every year; and it is about the period of this regeneration that certain round, earthy matters, used in medicine under the improper name of crab's eyes, are also met with in the stomach, their use being probably to co-operate with the teeth, at this period, in grinding the food. Similar teeth are met with also in the stomachs, or rather gizzards, of some kinds of grasshopper and beetle. The scorpion has a short gullet, and a long cylindrical stomach, which receives, at its lower part, the biliary vessels; while, near the lower part of the intestinal canal, is situated its venom-bag, in a depression in the last segment of the body; on this is fixed the horny sting, an aperture in the point of which gives exit to the poison, in the same manner as the perforated teeth of the spider and other animals, the bite of which is poisonous, conduct their venom. In the bee, the gullet and stomach are each very short and straight, but the former is dilated into a kind of crop, in which, apparently, the honey is prepared, and from which it

is afterwards ejected into the honey-comb; while in the latter is formed the wax, which, exuding through the rings on the fore part of the body, becomes collected in a depression on the thighs; the venom apparatus is analogous, both in its situation and structure, to that of the scorpion. In other insects, the several parts of the digestive apparatus are little more than a repetition of these; but I must not omit to remark that, all these parts are, in general, smaller and less complicated in the carnivorous than in the herbivorous tribes, apparently from the matters on which the former subsist being already animalyzed, and requiring, therefore, less preparation before they are received into the blood. It is worthy of attention also, that, while the insect is in a state of larva or caterpillar, the stomach is much larger than it is afterwards, most probably because a greater supply of nourishment is now required for its full development. In this state, accordingly, they are very voracious, and their digestion is proportionally quick; it having been computed that they sometimes devour and digest no less than three times their own weight of aliment in four and twenty hours! On the other hand, during the subsequent metamorphoses which the animal undergoes, no food is taken; but nature has beautifully provided against any necessity for this, by causing insects to become very fat, as observed by Malpighi, on the approach of these changes, so that this fat being absorbed

into the blood while these are going on, serves all the purposes of a supply of alimentary matters from without.

Let us proceed, next, to the vertebral animals. In many fishes the gullet is enormously wide; and in some it is furnished, like the tongue, and some other parts of the mouth, with regular teeth. In the myxine there are numerous openings from the gullet into the respiratory bags, which lie on each side of it; and, in the greater number of fishes, this canal opens into the air-bladder, a long narrow sac running down the body, close to the spine, and serving the purpose chiefly of enabling the animal to rise in the water, which it effects by inflating, at will, this sac with air. In some fishes, as in the sea-devil, the stomach is divided by a transverse constriction into two portions; but these divisions are still more remarkable in the shark, in which the right portion of the stomach is almost entirely distinct from the left, and assumes nearly the form of an intestine. In most fishes, the stomach is of that kind called membranous; but in a few, as the trout and mullet, it is of a fleshy, and almost cartilaginous consistence, like the gizzards of fowls, and so hard as to break the shells of those animals on which these fishes subsist. The intestinal canal of fishes is distinguished principally by the spiral or serpentine direction of the numerous plaits into which the internal membrane of it is folded; and which are believed, by detaining the alimentary matters in their passage

onwards, to enable fishes to endure, without inconvenience, the long abstinence to which they are sometimes subjected. The perch, according to Sir Everard Home, takes food only once a fortnight. The liver is in general very large in fishes; but many of them, as the perch, the lamprey and the lump, have no gall-bladder, or distinct receptacle of bile, before it is carried from the liver to the intestines. The whole intestinal canal is, in general, much shorter in fishes than in other animals, being sometimes not longer than their body; whereas, in most reptiles, except serpents, in birds and in quadrupeds, it is from three to thirty times that length—a provision unnecessary in fishes, perhaps from the matters on which they for the most part subsist being already almost of the same nature as their own bodies, and, therefore, requiring comparatively little preparation.

The gullet of some reptiles, as serpents, is equally wide, and even wider than that of fishes, this organ and the stomach being frequently almost of the same calibre, and together performing apparently one common function—that of digestion,—whereas, in most other animals, the gullet is merely the passage for transmitting the alimentary matters to the receptacle in which they are to undergo that change. It is well known that most serpents, after having bruised their prey, and smeared the surface with their saliva, devour the carcass whole; and the celebrated naturalist Spallanzani, not unfrequently

found one end of a frog, for example, perfectly digested in the stomach and gullet of a serpent, while the other, still living, was hanging from its jaws! In some reptiles, as the eft, the gullet is furnished with a crop or craw. The stomach of some reptiles, as the turtle, is, like that of the shark, divided into distinct right and left portions; while others, as the crocodile, have a kind of gizzard, like that of the trout and mullet.—The liver is very large in most reptiles, as well as fishes; and what is remarkable, all reptiles have a gall-bladder. We meet with in them also, for the first time as we ascend the scale of animals, a proper pancreas, or sweet bread; the place of this organ having been supplied, in most fishes, by a heap of blind tubes opening upon some part or other of the intestinal canal. The use of this organ is to supply a peculiar fluid, something like saliva, which co-operates with the bile, coming from the liver, in effecting the necessary changes in the alimentary matters. The whole alimentary canal is in some reptiles, as serpents, remarkably short, like that of fishes; while frogs, turtles and lizards, have it in general of the same relative length as most birds and quadrupeds.

The craw or crop is more remarkable in the gullet of the gallinaceous birds, than in that of any other animal; and in the pigeon there is besides, on each side of this passage, a spherical bag, capable of being distended with air, which gives the animal the appearance called pouting. It is in this class of animals also that that form

of stomach called a gizzard assumes its most characteristic appearance, consisting, as it does, of four distinct muscles—a large hemispherical pair at the sides, and a small pair at the extremity of the cavity. It is of an almost cartilaginous consistence, serving the animal for a kind of teeth; and such is its hardness and power of resistance of injury, that it has been found capable of breaking lancets and bending needles, which have been introduced into it, without itself undergoing the least injury. It appears also, that birds with this kind of stomach, are accustomed to increase its powers of attrition—as I have already noticed of the earth-worm—by swallowing small peebles, without which the digestive process would be imperfect; and it has been presumed that this kind of stomach has been given to herbivorous birds, in preference to the plurality of stomachs which herbivorous quadrupeds possess, because, while their digestive process is not less difficult, such a plurality would have been incompatible with the lightness requisite for flying. Carnivorous birds have, on the contrary, membranous stomachs, like carnivorous animals in general. The fluids formed in the gullet and stomach of birds are, in general, more copious than in those of other animals; and some birds, as the Java swallow, actually construct their nests of the viscid substance which, at certain seasons of the year, they pass from these passages! These nests, in appearance something like saucers made of isinglass,

are a well known luxury at the tables of eastern epicures, and are not unfrequently imported into Britain, and used in flavouring soups, and dressed dishes. Among birds, the liver is the smallest in the accipitrine, and the largest in the diving and wading species; in some of which, as the goose, it is sometimes artificially enlarged for the purposes of luxury, a practice which originated with the ancient Romans—who used to gloat over the

"Magno jecur ansere majus"

in the true style of epicurism—and is still prepared and used on the Continent, particularly in the composition of the celebrated Strasburg pies. The gall-bladder is wanting in many birds, as the parrot, ostrich, peacock, guinea-fowl, dove, pigeon, &c., whence, perhaps, has originated the epithet pigeon-livered, as applied to poltroons, who are represented as

"Wanting gall to make oppression bitter."

The gullet of quadrupeds, in general, presents nothing very remarkable. The stomach is in many species, as the hare and rabbit, divided by a transverse constriction into two cavities; while in others, as the kangaroo, it is drawn tight in several places, so as to give it a sinuated appearance. In the rat, the stomach is protruded into several distinct pouches, and similar pouches are attached to the left portion of the stomach of the

elephant, peccari, hippopotamus, sloth, and several other quadrupeds. From these the transition is easy to those in which there is a plurality of stomachs, as the porcupine, which has three, and most of the ruminating quadrupeds, which have two, three, or four, distinguished—when there are four—by the names of paunch, *(ventriculus)*, bonnet, *(reticulum)*, many-plies, *(omasum)*, and caille, *(obomasum)*. When the food is swallowed for the first time, it passes directly from the gullet into the paunch, where it undergoes some necessary changes, and it is then transmitted to the bonnet, to be mixed with the fluids of that cavity. This process is going on during the time the animal is grazing, when, from the incessant occupation of nipping off the grass, it has not leisure to chew it sufficiently. Upon its afterwards reposing itself, however, the half chewed aliment is brought again, in successive little balls, from the bonnet into the mouth, where it is now subjected to a perfect mastication; and, when again swallowed, it passes directly to the many-plies, thence, after some time, to the caille, and ultimately to the intestines. How beautifully is this structure adapted to the habits of the animal, and how strictly analogous is this second chewing to the action of the gizzards of the gallinaceous birds! But, perhaps, a still more striking example of the adaptation of the structure of animals to their habits is presented in the camel. In this animal, the paunch has two deep cellular appendages, and the bon-

net, or second stomach, has its internal membrane hollowed into numerous deep cells, all apparently serving as reservoirs of aliment, to be used only as occasion may require; while the third stomach is alone appropriated to the immediate necessities of the body. Between the end of the gullet, then, and the orifice of this third stomach, extends, through the two first, a long muscle, capable of drawing up the third stomach, so as to receive the alimentary matters directly from the gullet, when the immediate wants of the animal are to be supplied; but, when the food and drink taken are meant to be used only in its long journeys through the desarts, this muscle is relaxed, and the alimentary matters thus received into the two first stomachs, are transmitted onward by these, only at the necessary intervals. Among quadrupeds, the stomach is most muscular in the ant-eater and armadillo, and least so in the purely carnivorous, as the lion and tiger. In a very great number also, the gall-bladder is wanting, as in the sloth, rat, horse, camel, goat, deer, elephant, &c. The relative length of the intestinal tube is usually greater in herbivorous than in carnivorous quadrupeds, but not always, that of the sloth, for example, being scarcely equal in length to its body, while that of the seal is almost thirty times longer. I must not leave the digestive organs of quadrupeds without observing, that, when these are no longer put in requisition, as in the case of those that hibernate, as it is called, or sleep

away all the winter months of the year, nature has, as in the case of insects while undergoing their metamorphoses, provided against any inconvenience from this cause, by causing them to get very fat on the approach of winter, so that they subsist, during the period of their hibernation, on their own fat, which is gradually absorbed into their blood.

The next subject of consideration is the circulating organs, or those by which the blood, thus at intervals renewed, is carried to every part of the body. In the simplest orders of animals these organs of course do not exist; since, having no proper digestive organs, but assimilating the crude alimentary matters received by imbibition, equally in every part of the body, there can be no occasion for any system of vessels to carry these matters from one part to another. In the greater number of zoophytes, accordingly, proper blood-vessels are wanting, because they are destitute of a stomach and intestines; but as soon as these are met with, in the ascending scale of creation, they are found to be accompanied by proper vessels, for conveying the matters thus prepared throughout the rest of the system. We may thus, if we please, regard the circulating organs as a kind of appendage to those appropriated to digestion; and, indeed, the first rudiment of a vascular system, in animals, presents rather the appearance of elongated intestines than of proper blood-vessels. Such is the case in the

sea-blubber, in which certain vessels radiate from the stomach directly to the circumference of the body, where they open into a circular tube; but of the ultimate distribution of the fluids so carried we are entirely ignorant. In all probability these vessels collectively partake of the nature, not only of intestines, but at once of veins or absorbing vessels and of arteries; the former of which, in the higher classes of animals, serve to convey the blood to the centre of the circulation, and the latter to carry it to every part of the body. These two systems of vessels are for the first time quite distinct, as well from each other, as from the intestinal canal, in the earth-worm, in which one large vessel, apparently the chief artery of the body, runs along the back from the head to the tail, and two others, which seem to be veins, and one of which traverses in its passage the respiratory organs, along the lower part of the body again from the tail to the head, the two sets of vessels being connected together, about the neck of the animal, by several half-hoops, which meeting, encircle the beginning of the intestinal canal. Hitherto there is no heart, properly so called; but the half-hoops just mentioned, being not entirely tubular, but composed of strings of little rounded hollow bodies, which appear to be capable of contracting, and thus propelling their contents onwards, have been presumed to consist, as it were, of a series of little hearts, all conjointly performing the office of one great one. A distinct heart, however, as well as

arteries and veins, is met with in many of the Testacea, as the snail; and, among the Mollusca, the cuttle appears to have no fewer than three distinct hearts. In the former, the heart is situated immediately behind the respiratory organ, from which it directly receives its blood, and propels it by the main artery of the body to every part, whence it returns by the chief veins to the respiratory organ, and thence again to the heart. In the latter, while one of the three hearts, like that of the snail, receives the blood from the respiratory organs, and transmits it in a similar manner by the arteries and veins, the other two are situated at the extremities of the two chief veins, and serve to propel it through the respiratory organs preparatory to its again arriving at the first heart.

In insects in general, the progress towards perfection of the vascular system appears to be retrograde, but it is so in furtherance of an essential purpose in their economy—that of rendering them light, and therefore capable of flying. Accordingly, in the majority of these animals, the nutritive matters appear to be taken up by a kind of imbibition from their intestinal canal, and to become accumulated in one large blood-vessel, which runs along the back from head to tail, and from which no other vessels, except in some few insects, as the spiders, can be observed to arise, for the purpose of carrying the blood to the several parts of the body. We must suppose, therefore, that, as it is received by imbibition, so it is transmitted for the purposes of nourishment, by

a kind of exudation; while, in the mean time, numerous air-tubes, beginning from the surface of the body, are ramified over this single dorsal vessel, and serve to keep its contents in the requisite state of purity. In other animals, as we have seen, the blood is carried at intervals to the air, or other medium by which it is purified:—in most insects, on the contrary, the air is carried to the blood, and how conducive this must be to the end just alluded to, must be sufficiently obvious. The dorsal vessel, with the air-tubes distributed upon it, may be distinctly seen with a microscope, and even observed to pulsate, in the bee, the silk worm, and numerous other perfect insects; while in many of these animals in the state of larvæ, there is, according to Carus, a circulation of the blood more corresponding to that of other animals, the blood-vessels becoming obliterated only in proportion as they would have been inconvenient. And, accordingly, in many of the Apterous insects there is the usual complement of arteries and veins, and even a proper heart placed between the two. In the cray-fish, for example, the heart is situated immediately below the dorsal shield, being distinctly seen to pulsate when this is removed, and sends off several arteries both forwards and backwards; and in the soldier's crab the heart has a similar situation, and gives off its vessels in a similar manner.

Of the vertebral animals, the heart is single in fishes and reptiles, as it is in the two preceding

classes of animals, and double in birds and mammiferous animals alone; that is to say, it is, in the two former, appropriated either directly to the body in general, and only indirectly to the respiratory organs, or directly to the respiratory organs, and only indirectly to the body in general; while, in the two latter, one compartment of it is appropriated directly to the body in general, and the other equally directly to the organs of respiration. The heart of fishes is situated between their gills, or respiratory organs, and therefore in most fishes, close to the head. It is in general very small in proportion to the size of the body, not exceeding, upon an average, 1-550th part of the weight of the animal; whereas, in reptiles it is upon an average 1-250th; in mammiferous animals 1-150th; and in birds, not less than 1-85th of this weight. These differences are precisely such as the less or greater energy of the circulating powers in each of these tribes requires. The heart of fishes does not, like that of most of the animals of which we have hitherto been speaking, receive its blood from the respiratory organ, and send it directly into the arteries of the rest of the body; but it receives its blood from the large veins coming up on the lower part of the body, and directly transmits it by vessels, called the branchial arches, to the gills, whence it is conveyed by other vessels—the union of which, along the back of the animal, constitutes the main artery of the body—to all the rest of the system. The single heart of fishes is accord-

ingly commonly said to be a pulmonary heart, in contradistinction to that of reptiles, which is called a systematic one; and it is evident that the circulation of the blood in these animals must be at once stopped by preventing the action of their gills, since it is through these organs alone that the blood transmitted by the heart can reach the several parts of the body.

Among reptiles, the frog has its heart situated immediately below its breast-bone; and it receives its blood from the large veins of the body, in the same manner as that of fishes. It does not, however, like that of fishes, transmit this blood directly through the respiratory organs, and thence indirectly to the rest of the system, but at once, by the large arteries leading to the body in general, of which the arteries leading to the lungs are only branches; while corresponding veins, returning from the lungs, terminate in the large veins of the body in general, already in their course to the heart. It hence follows, that the course of the blood through the respiratory organs is not, in these animals, as it is in fishes, essential to its course through the rest of the system; since, while in the latter, the vessels of the gills constitute one portion of the great circle in which the blood moves, in the former, those of the lungs constitute only segments of smaller circles, attached to this great one, but not forming any part of it. It was the intention of nature that fishes should constantly inhabit the waters, in which their gills play freely and constantly,

and the circulation of their blood is therefore uninterrupted; but reptiles were destined to live at one time in the air, and at another in the water, and it became necessary, therefore, to give them a circulating apparatus, which could perform its office equally well, whether the animal was respiring, as it does while in the air, or had for a time ceased to respire, as is the case when it is beneath the water. Some of the higher orders of reptiles, as the tortoise and the alligator, make an approach to the double heart of birds and quadrupeds, that is to say, while it is in structure still more or less a single heart, it is in function—at least so long as the respiratory organs are in action—almost a double one; the right side of it receiving principally the impure blood from the large veins of the body, and sending it through the lungs, while the left side receives chiefly the purified blood from the lungs, and transmits it by the main artery to the rest of the system. This, however, is the case only when respiration continues unobstructed; since, upon the animal's descending below the water, both sides of the heart co-operate more or less in receiving the blood from the body in general, and in transmitting it again to the body, the right side, which, under other circumstances, transmits it principally to the lungs, now sending it, in common with the left, to the body in general; and the left side, which, under other circumstances, receives it chiefly from the lungs, now receiving it, in common with the right, from the large veins

of the body. The greater perfection of the organization of these tribes seems to have required that the blood should be in general, more decidedly of two kinds—arterial and venous—than was necessary in those of a lower grade ; while, at the same time, their amphibious habits did not allow of the distinctly double heart which is proper to birds and mammiferous animals, the respiration of which is not liable to be in the same way impeded.

In birds, for the first time, we meet with a heart double, as well in structure, as in function; the right compartment of it being constantly and exclusively pulmonary, and the left equally constantly and exclusively systematic; and though these two compartments are united into one heart, and placed on one side of the body, they would have performed their distinct offices perhaps equally well, had they been quite separate from each other, and placed one on one side of the body, and the other on the other. The right cavity of the heart of birds gets its blood, like the single heart of fishes, from the large veins of the body, and transmits it through the respiratory organ ; whence, on its return, it passes, not, as in fishes, directly into the large artery in the course of the spine, but first into the left cavity of the heart, by which it is propelled, as by the heart of the frog, into the artery in question, to be at length returned to the right cavity by the large veins. In this course the blood is directed —as it is also through the heart and large vessels

of fishes and reptiles, but in a less remarkable manner—by valves of a most complicated and curious structure, one separating the upper from the lower portion of each cavity of the heart, and one again at the origin of each of the large vessels, going, the one to the lungs, and the other to the body in general. Of these valves it is sufficient to say, in this place, that, while they admit the free passage of the blood in the course which the purposes of the circulation require, they effectually prevent one drop from passing in an opposite direction; and that the structure of these valves alone is sufficient to carry ample evidence to the minds of all but the voluntary blind, of a directing hand, infinite alike in wisdom and in power. The coats of the arteries in birds are thicker and stronger than in other classes of animals, corresponding to the greater energy of the heart.

The heart of mammiferous animals receives and transmits its blood almost entirely upon the same plan as that of birds; and is provided with valves of a similar structure, and for the same purpose. The arteries going to the brain of grazing quadrupeds present the peculiarity of being subdivided, and again collected into trunks, before penetrating that organ; for the obvious purpose of diminishing the impulse of the current of blood towards the brain, in those animals in which, from their holding their heads so continually downwards, this impulse is greater than natural. The same peculiarity is observable in the arteries going to

the members of the sloth, lory, and other tardigrade animals, as they are called, the slow pace of which renders a supply of blood with the usual impulse unnecessary. With respect to the veins, also, there is a peculiarity in the large trunks of this system in the seal, sea-otter and other diving quadrupeds, which merits attention, as displaying a beautiful example of adaptation in the structure of organs to the habits of the animal in which they are found. From what has been said under the head of the circulation of fishes, it will be obvious that that of quadrupeds must be immediately stopped when the lungs cease to act; since the passage of the blood from the right side of the heart to the left can take place only through these organs. When, therefore, an animal of this description is under water, the blood has a tendency to accumulate in the lungs, which can no longer transmit it forwards, and would rapidly produce suffocation, if it were not, by some means or other, kept from them. Now, nature has given to the animals just mentioned, as well as to others habitually exposed to the same impediment of the respiratory process, a large pouch in the course of their chief vein, in which the blood, hurrying towards the right cavity of the heart and the lungs, becomes collected during the suspended action of the latter; and suffocation is thus obviated, till, on the ascent of the animal again to the surface of the water, the blood freely repasses through its natural channels.

The last subject which is to occupy us at present, is the respiratory organs, or those by which the blood, received into its vessels from the alimentary canal, is, during its subsequent circulation through the body, kept in a state of requisite purity. This is in all cases effected by bringing it, at intervals, into contiguity either with atmospheric air alone, or with water containing this air diffused through it; when, such is the mutual action of the blood and the air upon each other, that the former is purified, and passes in general from a dingy purple to a bright scarlet colour, while the latter is, in the same degree, rendered impure, and after a time becomes inadequate to support either respiration or combustion. In the simplest forms of animals, most of the zoophytes, for example, respiration seems to be what is called by St. Hilaire, interstitial, that is to say, to go on in every point of their bodies equally; the best glasses having failed in detecting any specific apparatus for the purpose, although it is known that they do respire, by the changes which the air, left for a certain time in contact with their bodies, is found to have undergone. In some of these, however, as the branched polype and sea-feather, as well as some testaceous and mollusous animals, as the sea-urchin, star-fish, sea-anemone, &c., the arms, tentacula or animal blossoms, which they respectively put forth, are, in all probability, like the leaves of plants, more particularly adapted to respiration; although no specific pores for this

purpose, like those in leaves, have hitherto been detected in them. Perhaps the simplest form in which a distinct respiratory apparatus displays itself in animals, is that of gills, such as are met with in most of the aquatic mollusca, as the fresh-water mussel and the cuttle. In the former of these are three pairs of gills, one about the mouth, and two running down on the sides of the body—the one exterior and the other interior. They lie within what is called the *cloak* of the animal, a thin membrane with a fissure at its posterior part to admit the water, charged with air, to the surface of the gills; and this water, after having performed its office in purifying the blood which circulates through the gills, is squeezed out again by the closing of the shell. The cuttle has one pair only of leaf-shaped fringed gills, lying also within its cloak, to the inner surface of which they are tied down by ligaments, and by an opening in which the water is admitted; while it is afterwards squeezed out by the contractions of this cloak—the cuttle having no investing shell—which is accordingly thick and fleshy for the purpose. Another form of respiratory apparatus is met with in the terrestrial mollusca, which respire air and not water. This in the common garden snail occurs in the form of a bag placed immediately opposite to the upper part of the shell, and opening at the aperture of the shell, towards the right side; the ingress and egress of the air being regulated by a proper muscle which surrounds the opening. The vivi-

parous snail, on the contrary, which is an aquatic animal, and in which this respiratory bag would be useless, is furnished instead of it with regular gills. Lastly, in some animals of this class, the respiratory apparatus consists of a series of small blind tubes, running along the body, on the surface of which they open, and apparently adapted equally well to the respiration of water and air; since they are found, among the aquatic animals, in the leech, and, among the terrestrial, in the earth-worm. These tubes are traversed, as I have already remarked when speaking of the circulation of the blood in the earthworm, by one or two veins which return the blood to the chief artery; but as the course of the other vein is quite independent of these tubes, it is easy to understand why the circulation is not immediately stopped in these animals, by a stoppage of respiration. In the snail and cuttle, on the contrary, any impediment to the action of the respiratory organs, immediately stops the circulation of their blood, the heart receiving its blood exclusively from these organs, preparatory to sending it through the body in general.

The respiratory apparatus of insects is very similar to that of worms, in so far at least as it consists of either gills, respiratory bags or tubes; although the two latter are in general much more complicated in their structure, and diffused more or less throughout the whole body of the animal. As an example of an insect breathing

by gills we may take the cray-fish, in which the gills are situated on the sides of the animal at the base of the feet, and separated from the other internal organs by a horny plate, consisting of distinct pieces, something like the parts of the chest in the higher tribes of animals: it is furnished also with two other horny pieces attached to the jaws, by means of which the water, already vitiated by the contact of the gills, is expelled from their surface. The bee again presents an example of insects which breathe by respiratory bags, of which it has two, opening on the surface of the body by two holes—stigmata, as they are called—and giving rise to several branched tubes. On the other hand, the respiratory apparatus of the grub of this insect, as indeed of most others, is exclusively tubular; and these tubes have a very different distribution from that which they present in the perfect insect. The same is the case with the caterpillar of the silk worm; but even in the perfect animal, in this instance, the respiratory apparatus is tubular alone. Of these tubes one large one runs along each side of the body, and gives off, opposite to each of the numerous openings upon the surface, two sets of branches, one to the lower part of the body, and the other to the upper, in such a manner that the former branches go chiefly to the muscles moving the feet, and the latter to the dorsal blood-vessel, and to the several entrails, which in insects are always situated near their back. The stigmata, or orifices of the respiratory tubes,

in the caterpillar of this insect are furnished with a kind of lips, which open or close them at pleasure; and it is probable, by a similar apparatus, that all terrestrial insects regulate the ingress and egress of the air employed in respiration. But some terrestrial insects are capable of respiring even under water; and the means by which they do this is extremely curious. In general they carry down with them a considerable portion of air in the interstices of the hairs with which their bodies are covered, and which, continually exuding an oily fluid, prevents the water from coming in contact with it: they breathe, therefore, under these circumstances, in a kind of natural diving-bell. In some insects, however, as the water-scorpion, the air-tubes instead of this contrivance are provided with long processes extending from the posterior part of the body, the extremities of which being always above the water, furnish them with a constant supply of fresh air. They are, in fact, a kind of water-serpent, or cetaceous animal, in this respect; the bulk of their bodies being under water, while their spiracles, or the holes through which they breathe, are above it. I have elsewhere mentioned that, in all insects which fly, it seems to have been the object of nature to carry rather the air to the blood, than the blood to the air; and how excellently adapted to this purpose is the tubular and ramified structure of their respiratory apparatus, must be sufficiently evident.

Fishes in general, like the aquatic mollusca, breathe by gills, which consist commonly of four lobes or plates, on each side, of a red colour, floating loose in the water at their fringed extremity, but by the other attached to semicircles of cartilage or bone. These, which are called the thoracic ribs of the animal, are placed on the sides of the upper part of the gullet, and supported by the same bone which supports the tongue, being connected to each other by layers of muscle, by which the gills are kept in continual motion. The water reaches them by the mouth, through four clefts on each side; and having passed over the gills, is squeezed out by the descent of the gill-flap, or moveable lid by which the external portion of each gill is covered. The collective surface presented by these fringed lobes, or the part where the blood of the animal comes into contiguity with the water which is to purify it, is enormous—so much so, that it has been computed to be, in a fish of the size of a skate, not less than between four and five hundred square feet; and, as all these parts have to be kept in motion in so dense a medium as water, nature has given to fishes extremely large nerves and strong muscles for the purpose. It is not however always by gills, properly so called, that fishes breathe; some of them, for instance the myxine and lamprey, using a different kind of apparatus in respiration. In these animals there are placed on each side of the gullet several small tubes, leading to little vescicles

situated on the inside of the thoracic ribs: into these the water passes from the gullet, and is afterwards forced out again, in the myxine, by one common tube leading again to the gullet, but in the lamprey, by an equal number of openings on the sides of the neck. Perhaps also the air-bladder, of which I have already spoken, is, in those fishes that have one, a second respiratory organ; but its chief use is probably that of enabling the animal to rise at pleasure in the water.

The respiration of reptiles, though more similar to that of birds and mammiferous animals, still differs from it in some remarkable particulars. The former are indeed furnished, like the two latter, with a kind of lungs; but, unlike them, they have membranous, and not fleshy lungs, that is to say, the cells which they contain are so much larger, as to give them a membraous and not a fleshy appearance—nay, in many reptiles, the lungs consist of one membranous bag very similar to the air-bladder of fishes. These lungs, or bags, are situated in the abdomen—for reptiles having no diaphragm or midriff, have no chest properly so called—and are loose and floating among the entrails; and they receive their supply of air in general, not, as in birds and mammiferous animals, in consequence of the formation of a vacuum around them, but by a process very similar to that of swallowing. In this process the broad lingual bone is first drawn down by its proper muscles, and the air of the

mouth being thus rarified, a fresh supply enters by the nostrils, which are furnished with a valve, by which its subsequent escape is prevented. The lingual bone is then forcibly raised by the large pendulous muscles of the jaws; and the air, having no other passage, is necessarily forced into the lungs. Hence reptiles, unlike the higher classes of animals, can still continue to breathe if their bodies are cut open, because they do not require a vacuum round their lungs, but not if their jaws are held apart, since the air, which should have entered the lungs, is in this case forced out by the mouth. The air, thus received, is subservient to the purification of the blood in the usual manner; but it is not so immediately vitiated as air received into fleshy lungs, owing to the larger size of the cells, which do not immediately allow the whole of it to come into contact with their sides. This is one reason why reptiles can sustain an impediment to their respiration for a much longer time than birds and mammiferous animals; but another, and a much better reason is to be found in the distribution of their blood-vessels, those going to the lungs, as I have before explained, not forming a necessary part of the general circulating system, but constituting, as it were, only an appendage to it, which may for a time cease to transmit blood without inconvenience. In both these respects, however, we cannot but discern the hand of a ruling Providence, adapting the structure of animals to the habits which are to characterize

them. A fish was destined to be always in the water, and a bird or quadruped always in the air; and hence the structure of their respiratory, as well as circulating system, is such as to incapacitate them each for the other element; but a reptile was intended to be sometimes in the one, and sometimes in the other, and both systems are accordingly so constructed as to allow of this. Further, some serpents, the hydrus bicolor, for example, are enabled to continue under water for an indefinite time by a provision similar to that which I have already described, as found in the water-scorpion among insects, being capable of bringing the upper part of their wind-pipe almost to a line with the point of their lower jaw, so that they can breathe, although scarcely any portion of them is out of the water.

Before quitting reptiles, it is proper to observe, that there are individuals of this class, for instance, the proteus and siren, which, with respect to their respiratory organs, may be considered as composed of fishes and reptiles, being furnished at once with gills and lungs; or perhaps, with more propriety, as fishes, with a more developed air-bladder. The tadpole, a larva of the frog, during its metamorphosis presents a somewhat similar structure, the gills only gradually disappearing, in proportion as the lungs become developed.

In birds, the lungs instead of being membranous are fleshy, and instead of being loose and floating, as in reptiles, are tightly bound down to

the spine. As, among invertebral animals, insects in general, so, among vertebral, birds have the most perfect respiratory apparatus; although perhaps the real lungs of birds, or those organs in which the blood is purified, are not relatively larger than those of mammiferous animals. It is peculiar to the former, however, to have their lining and and investing membranes prolonged from various parts of their surface in the form of tubes, which, expanding into bags, envelope almost all the entrails, so as to keep them constantly surrounded with air; and similar prolongations, extending also from their back part into the cavity of the bones, serve to inflate these in the same manner. The chief object of this peculiarity appears to be that of giving lightness to the animal, and thus of enabling it to support itself in the air; and the same object is fulfilled in insects, as we have already seen, in a manner very analogous. But do we ever meet with this general diffusion of air through the bodies of animals not designed for flying—in worms, fishes, reptiles or mammiferous animals—as should at least sometimes have happened, had a blind chance, and not an omniscient Providence presided over their structure? Another thing remarkable in the respiratory apparatus of birds, is the provision made by nature, for the necessity which some of the wading and diving kinds are under, of remaining with their heads for a long time under water. She has not given them tubes opening upon the atmosphere, as in some water insects, nor large

cellular reservoirs of air, as in reptiles in general; but, she has made their windpipe of an immense length, and laid it in folds behind their breast-bone, so that sinking their heads into the water with this full of pure air, they can support respiration for a long time upon its contents alone. This structure is beautifully seen in the male crane. The ribs of birds, by the motions of which the common cavity of the chest and abdomen—for they, like reptiles, are destitute of a midriff—is expanded, and air drawn into the lungs, and, through the lungs, into almost the whole body, are unprovided with elastic cartilages, such as are met with in mammiferous animals; but they have, instead of them, perfect joints about midway between the spine and breast-bone, by which, when bent, the general cavity is constricted, and, when straightened, it is dilated, the breast-bone either approaching or receding from the spine, according to the angle which these joints form.

In the mammalia, as well as in birds, the lungs are fleshy, and each is, in like manner, bound down to the spine; there are, however, no longer any external orifices, by which air is transmitted thence to other parts of the body. In the cetaceous mammalia, however, or those that live in water, the lungs are commonly continued for some space down the spine, so as to remind us of the air-bladder of fishes. In these tribes also the nostrils, in which the wind-pipe terminates, open, not near the mouth—their usual

situation—but at the top of their heads ; so that the spiracles or air-holes continue above water, when all the rest of the animal is below it, and in this way, like the prolonged tubes in some water-insects, and the elevated wind-pipe in some water-serpents, keep up respiration. Further, many of these tribes, as the spermaceti whale, have large cavities in their skulls filled with liquid fat ; which, being lighter than water, enables them, without any effort, to keep a part of their heads constantly above the surface. When these animals descend entirely into the water, the entrance of this fluid into their lungs is prevented by a valve, with which the spiracles are furnished, and which, while it prohibits the ingress of water, allows of the free egress of that received by the mouth ; and it is in this way that these remarkable fountains are formed which characterize the animals in question. They cannot, however, continue long under water ; and it is from the necessity which they are under of rising frequently to the surface for fresh air, that we are enabled to capture them. Mammiferous animals, like birds, inspire by enlarging the cavity in which the lungs are contained ; but this, in the former, is the chest alone, which is now for the first time, separated from the abdomen by a proper midriff. This organ is, moreover, in them a principal part of the respiratory apparatus ; for, while the chest is rendered broader and deeper —owing to the projection forwards of the breast-bone—by the motion of the elastic ribs, it is ren-

dered longer also, by the descent of the arched midriff. What they gain in this way, however, is less considerable, than what they lose by the smaller scope of action in their ribs, than in those in birds; so that, after all, birds have, of all vertebral animals, the most extensive respiratory, as well as the most energetic circulating apparatus.

CHAPTER V.

FUNCTIONS OF ANIMALS AS ADAPTED TO THEIR MODES OF LIFE.

Smell, Sight, Hearing, Taste, Touch and Loco-motion.

In the preceding chapter I endeavoured to display some of the admirable adaptations of the structure of organs in the various classes of animals, to the functions they are destined to perform: the possession of which is less distinctive of the animal kingdom, than those of which I have now to speak; since vegetables, as well as animals, imbibe and digest their aliment, move their fluids, and bring these in turn into contiguity with the air by which they are purified: they do not, however, display equally evident marks of sensation and voluntary motion; and these are accordingly generally set down as the characteristic functions of animals. It would not perhaps be difficult to shew that this distinction is less decided than is commonly imagined—that many vegetables do, in fact, both feel and move in the same manner as animals—but whether they do or do not, it will still be admitted that

the indications of these functions are much less manifest in the former than in the latter, which is not the case with those already spoken of; so that we may still adopt this as a convenient, if not a precise line of demarcation between the two. I shall accordingly devote the present chapter to a short description of the several organs, by which, in different animals, the functions of smell, sight, hearing, taste, touch and loco-motion, are respectively performed.

In quite the lowest orders of animals the organ, if any, specifically appropriated to smell is in general very obscure, although some of them in which this is the case—the cuttle for example—display this function very remarkably. It is, perhaps, in most of them, merely a modification of touch, and performed equally by every part of the surface of the body. In the snail the seat of smell has been commonly considered to be their short feelers; but apparently without any good reason.

Insects in general smell very acutely; and in them the seat of this function has been at different times supposed to be their stigmata, or air-holes, their palpi, or commonly reputed organs of taste, and their antennæ, or organs of touch in general. In the cray-fish, which is one of the few insects that have a sufficiently obvious olfactory nerve, it is manifestly their smaller antennæ, at the root of which the nasal cavities are situated. In this animal, however, as well as in all aquatic animals, smell is rather a modification of taste

than a distinct function, the vehicle of the impression being, not air, but water.

Such is the case, of course, in all fishes, in which the nasal cavities are situated, in general, on the sides of the snout; and are lined by a plaited membrane, for the distribution of the proper nerve. These cavities have, however, no internal opening, so that there can be no perfect current of the fluid through them; but the distance at which some fishes scent their prey is nevertheless immense.

In reptiles, the nasal cavities have both an internal and external opening; the former being, in frogs, turtles and serpents, in the palate, but in lizards, in some of which, as the crocodile, they are exceedingly long, in the pharynx, or muscular bag at the back part of the mouth. Most reptiles also, have a kind of moveable lid at the aperture of their nasal cavities, by which they close them when under water; this medium being apparently but ill adapted, in them, to the function of smell. The proper vehicle of the impression in reptiles, as well as in birds and mammiferous animals, is air; and this the former draw through their nasal cavities during inspiration, effected, as I have already explained, by depressing their lingual bone, and thus enlarging the cavity of the mouth.

In birds, the nasal cavities are in general very large, their external aperture being in the upper mandible, and their internal in the pharynx. The olfactory nerve is very large in carnivorous birds,

and its great size, together with the great length of the nasal cavities, serves to explain the immense distance at which some of them—the vulture for example—are known to scent carrion: it is said to be capable of doing this over the whole breadth of the Mediterranean!

The nasal cavities of mammiferous animals run in general horizontally; but, in the cetaceous tribes, as I have already said, their inclination is perpendicular, the outer opening being at the top of their heads. Many animals of this kind, as the porpoise, the whale and the narwal, are generally regarded as destitute of smell, since they have no proper olfactory nerve; and certainly the hard and dry lining of their nostrils, like that of the proboscis of the elephant, is apparently very little adapted to this sensation. The projecting bones, by which the nasal cavities are, in most animals, more or less divided, are, in quadrupeds, extremely complicated, being, in most herbivorous species both variously convoluted, and pierced sometimes like lattice work; and, in most carnivorous, lamellated like the leaves of a book—a structure calculated, by increasing the surface, together with the great length in general of their snout, and the large size of their olfactory nerves, immensely to increase the acuteness of their smell. The "intellectual noses," as they are called by Lord Byron, of dogs are proverbial; and the distance from which many other quadrupeds, particularly such as are carnivorous, are sometimes attracted by

the smell is wonderful—white bears for example, being found to come swimming to the Greenland ships, when a whale is cutting up, from all quarters, and far out of sight. Some quadrupeds, as the hog, the peccari and the tapir, have a remarkable power of moving the extremity of their snout; but this is probably less for the purpose of smell, than for that of burrowing, &c., their snout being to them, as its proboscis is to the elephant, a kind of hand.

With respect to sight, it is equally doubtful as with respect to smell, whether there be any specific organ for this function in quite the lowest tribes of animals; although some of them, as the armed polype, the sea-feather and some corallines certainly do see, or at least are capable of distinguishing light from darkness, the former being always found to move towards the light, and the two latter from it. It is, however, probably by a kind of touch that they do this, rather than by sight, properly so called; and of this the numerous papillæ on the surface of the body may be presumed to be the chief instruments; so also the first appearance of distinct organs of vision is that of stemmata, as they are called, or small knobs, more or fewer, projecting from the surface of the body, as is the case in the leech; and what are regarded as the eyes of the snail are little more than similar knobs, placed at the extremity of their long feelers, and capable of being retracted by the muscles of the latter, into which

they descend, as into the inverted fingers of a glove. Organs of this kind may serve, indeed, to distinguish between light and darkness ; but it is impossible that they can convey any impression of distinct images of objects, since they have not the conditions necessary to produce such refractions of the rays of light as are essential to this end. Among the few animals of this description, which are provided with proper eyes, is the cuttle, in which those organs are very large and prominent. They consist essentially of a dense opake globular membrane—the sclerotic coat—filled with a transparent fluid, enveloping a small lens, and smeared on its concave side with a black pigment, the use of which is to absorb the superfluous rays of light, and immediately under which lies the retina or expansion of the optic nerve. This membrane is perforated anteriorly by a kidney-shaped pupil, through which the rays of light are transmitted to the retina ; and over the whole is extended a second membrane, so folded on itself, as to constitute a kind of eyelids.

Similar to the stemmata of some worms are what are called the simple eyes of insects ; and such alone are found in the spider and scorpion: they seem to be organs rather of touch than of sight, although they have been presumed by Blumenbach to serve to distinguish near objects. Very different from these are the so called compound eyes of insects, such as are met with, without any rimple eyes, in the beetle and butterfly ;

while others, as the bee, have both. They are for the most part extremely large; varying, however, between about one-sixtieth and one-fourth part of the weight of the whole body. Their structure is eminently beautiful; consisting, as they do, not of coats and humours, but principally of a series of pyramids of nervous substance connected together, the apices being on the bulbous extremity of the optic nerve, and the bases, invested each by a thick transparent membrane of a hexagonal shape, at the circumference of the eye. This membrane, presenting thus numerous facets, which look in every direction, is called the cornea, and seems to be in insects the only instrument of refraction, the images of objects being most probably impressed, by this means, directly on the base of each pyramid, which is thus a kind of distinct eye. They have no lens and no pupil, or rather the whole surface of the cornea is one large pupil, there being no opake coats to render a proper pupil necessary; and they are destitute both of eye-lids, and of muscles to move the eye, the numerous directions of the facets of the cornea rendering the latter superfluous. How strikingly different is this description of eye which characterises insects which fly, and require therefore an ample field of vision, from the simple eye found in the grovelling kinds, which either do not see, strictly speaking, at all, or certainly only quite contiguous objects! Further, in insects which fly by night, like the moth, there is, in place of the black pig-

ment lately mentioned as found in the cuttle, a substance of a resplendent green or silvery colour, serving not to absorb, but to reflect the rays of light; and thus enabling them to see by a much more obscure light than would otherwise have been necessary.

Among vertebral animals, fishes have an eye somewhat similar to that of the cuttle; consisting essentially of a spheroidal sclerotic coat, containing the chief humour of the eye, a lens which, as in the cuttle, is almost globular, and a retina, which is often plaited, as it were, into numerous folds, arranged like the meridian lines on a globe. They have, however, in addition, a proper cornea like insects, presenting, not indeed numerous facets, but one uniformly convex surface, although the convexity is very slight; and they have further, what insects have not, a perfectly formed iris, or circular curtain, placed before the lens, in which, and not as in the cuttle in the sclerotic coat, the pupil is situated. The rays of light accordingly traverse, in these animals, first the transparent cornea, and afterwards in order the anterior portion of the humours of the eye, the pupil, the lens, and the posterior portion of these humours; by all which, except the pupil, they are more or less refracted, till they are at length brought to a focus on the retina. The chief peculiarity in the eyes of fishes, as contrasted with those of the superior tribes of animals, is the comparative flatness of their cornea, and convexity of their lens; it appearing to have been the object of nature to

effect the necessary refraction of the rays in them principally by the latter; the iris, moreover, in fishes, is almost entirely motionless, so that the size of their pupil is always nearly the same. In general they are destitute also of proper eye-lids; the eye-ball moving behind the common integuments—to which it is attached by very relaxed cellular tissue—as behind a piece of thin glass or horn. In some few fishes, however, as the sun-fish, Cuvier has found a regular circular eyelid, the opening in which is contracted by a sphincter, and expanded by five radiating muscles. The direction of the eye-balls is usually outwards; but in some few fishes, as the star-gazer, it is upwards; and in the plaice, flounder, dab, halibut, turbot, &c., the eyes are placed both on one side of the body—an isolated instance, according to Blumenbach, of a want of uniformity in the two sides. The object, however, of such an arrangement in this instance is obvious, for as these animals, destitute as they are of an air-bladder, are destined to continue always with one side in the mud at the bottom of the water, an eye on this side would have been superfluous to them. The most singular situation of the eye-ball, however, is that of the Surinam sprat, the orbit extending in this fish, so far above the head, that the eye, as the animal swims near the surface, is partly in and partly out of the water; and all its parts correspond with this strange structure, the pupil being partially divided into an upper and a lower portion, and the lens con-

sisting of two globes, an upper and a lower one, attached together. It appears that the superior part of the eye is, like that of terrestrial animals, adapted to refract rays transmitted by air, and the inferior part, like that of aquatic animals, those transmitted by water; and that the refracting power of the several parts of the eye is accordingly much less above than below. It remains only to remark, that in some fishes, as the skate and shark, there is, as in insects that fly by night, a resplendent substance at the bottom of the eye-ball, instead of the black pigment which is usually found there; its use being rather to increase than diminish the number of rays which fall upon it.

The eyes of reptiles in general do not differ materially from those of fishes, except that they appear to possess the power, of which those of fishes are destitute, of adapting themselves to refract rays as transmitted either by air or by water. I have already hinted when speaking of the singular eye of the Surinam sprat, that the refracting power required is different in these two cases, as any one may satisfy himself by attempting to distinguish minute objects placed in water, with his head likewise immersed in this fluid. The reason that he cannot do this is because, though there is a sufficient difference between the density of the humours of his eye and that of the air, to bring the rays transmitted by the latter to a focus on the retina, there is not a sufficient difference between

the density of these humours and that of water, to do the same by rays transmitted by this fluid, so that such rays are not brought to a focus sufficiently soon. Hence, divers in some places, are in the habit, when they descend into the water, of using extremely convex glasses, in shape almost like the lens of fishes, and turning their eyes by this means, as it were, into those of an aquatic animal. But how do reptiles manage this? Not by using spectacles, nor by increasing the density of their humours; but by increasing the distance between the cornea and retina—which they effect by compressing the globe of the eye by proper muscles given to them for that purpose—so that the rays which, from the defective refracting powers of their humours, would have otherwise formed a focus *beyond* the retina, now form a focus *upon* it. When again in the air they relax these muscles, and the retina again approaching the cornea, still receives the focus of the rays, which, as passing now through air, are sufficiently refracted for the purpose. Whether we regard then the heart and blood-vessels, the respiratory organs, or those of the senses, in these tribes, we trace equally distinctly the main object which nature had in view in their construction. The motions of the iris in reptiles—now for the first time perceptible—are still extremely languid, and the form of the pupil is very various, being rhomb-shaped in the frog, vertically oval in the crocodile, &c., but this probably makes no difference in the phenomena

of vision. With respect to eye-lids, all reptiles are furnished more or less perfectly with these, except serpents, which, in being destitute of proper eye-lids, resemble most fishes. The direction of the eye-ball is, as in most fishes, commonly outwards; but in the crocodile it is, as in the star-gazer, a little upwards as well as outwards, obviously for the purpose of enabling the animal to see its land prey, as it floats leisurely just beneath the surface of the water. Reptiles have also all of them, again excepting serpents, another organ which all fishes want—namely, a lacrymal gland, the secretion from which serves to bedew the anterior part of the eye with moisture, and thus to facilitate the motions of the eye-lids. Such an organ would evidently have been quite superfluous in fishes, which are always under water; but it is particularly necessary in amphibious animals, which, when on land, must furnish from their own resources a fluid so abundantly supplied to them when in the water, from without. This gland is accordingly of immense size in turtles; and the allusion to crocodile's tears, as flowing easily and copiously, is familiar to every body.

The eyes of birds are remarkable principally, like the compound eyes of insects, for their great size, the use of this being in both the same—that of enabling them, when on the wing, to see objects at a great distance. With respect to the cornea and lens, they are directly opposed to those of fishes; since, while the cornea is com-

paratively flat, and the lens almost globular in fishes, in birds the cornea is remarkably prominent, and the lens has very little convexity. The motions of the iris in most birds are extremely rapid, and in some apparently voluntary. The pupil is in some, as the dove and the goose, transversely oval, while it is vertically oval in others, as the owl: generally speaking, indeed, it has the former shape in herbivorous animals, whether birds or quadrupeds, and the latter in carnivorous. All birds have proper eye-lids, the lower of which alone is moveable; and they have, in addition, another membrane called membrana nictitans, which is merely a moveable fold of the external membrane of the eye-ball: it is not quite proper to birds—being found also in some fishes and reptiles—but it is most remarkable in them. With very few exceptions—the owl among others—the direction of the eye-balls is, in birds, outwards. Such birds also, as well as insects and fishes, as go in search of their prey by night, like the owl, have a shining substance at the bottom of the eye-ball, for the purpose already alluded to. In some birds with piercing sight, as the falcon and crane, the flattened optic nerve has one of its surfaces folded into numerous plaits, bearing the same relation to to the other as the leaves bear to the back of a book; and the extent of surface thus gained may be easily imagined.

Among the mammiferous animals, the cetaceous tribes, as we should expect from their habits,

have eyes very similar to those of fishes; the cornea being comparatively very flat; and the lens almost globular, while they are destitute of proper eye-lids—a kind of membrana nictitans alone supplying their place—and of a lacrymal gland. In the other tribes the comparative convexity of the cornea and lens is intermediate between that of these organs respectively in fishes and birds; while the motions of the iris are the mean, as it were, of those of reptiles and birds: in some quadrupeds, morever, as the cat, they seem to be in some degree voluntary. The form of the pupil is transversely oval in the pecora and solidungula, and vertically oval in the Feræ; consistently with what I have already remarked upon this subject. The direction of the eye-balls is in most mammiferous animals outwards; in the ape however, baboon, monkey, and some few others, it is, as in man, directly forwards: further, in some quadrupeds, as the camel-leopard, the eye-ball, though naturally directed outwords, may be turned so far backwards as to enable the animal to see distinctly behind it. Like the nocturnal animals, also, of other tribes, quadrupeds which prowl by night, such as the lion, lynx, cat, bat, &c., have the structure which I have already more than once described, as calculated to enable them to distinguish objects in comparative darkness. On the other hand, where the habits of the animal are such as to exclude it altogether from the light, as no structure of the eye could have com-

pensated for the want of this essential condition of sight, nature has denied them a visual apparatus altogether—as in the case of the mole, which has no optic nerve, and an eye so small, that its existence has been doubted.

We come next to the function of hearing. In the very lowest tribes of animals it appears that this function, like those of smell and sight, is merely a more delicate kind of touch, and performed equally by the whole surface of the body. The greater number of animals of this description have no obvious auditory apparatus, the cuttle being among the few exceptions, and furnishing, perhaps, the best example of an ear in its rudimental state. In this animal it consists merely of a membranous bag filled with liquid, situated in a tubercle of the cartilaginous ring which surrounds the gullet, and surrounded on all sides by cartilage. Upon the outer surface of this bag is distributed the auditory nerve; while, within the liquid which it contains, are some little pieces of earthy matter, presumed to be necessary to render the vibrations of the liquid, on which sound depends, sufficiently forcible to make the requisite impression on the nerve.

In the greater number of insects, also, the auditory apparatus is very obscure; although it is certain that they do hear, and even very acutely. The immediate seat of the function has been presumed to be the membrane which connects their antennæ with the head—but spiders hear which

have no antennæ, and grass-hoppers after these have been removed. In all likelihood, it is in the majority of insects merely a variety of touch, and common, therefore, to the greater part of the surface. In such insects as present any appearance of a distinct auditory apparatus, as the cray-fish, it is very similar in its structure to that of the cuttle; consisting, in like manner, of a bag filled with liquid—situated, in this instance, in a bony cylinder at the root of the larger antennæ—an auditory nerve expanded upon it, and some pieces of earthy matter in the liquid which it contains. In the cray-fish, however, unlike the cuttle, the bag in question is not surrounded on all sides by the hard mass which contains it, but is, near the surface of the body, in contact with a thin membrane—the first approach to the external parts of the auditory apparatus, as met with in the higher tribes of animals.

Nor is the auditory apparatus of most fishes much less simple than that of the invertebral animals. The membranous bag, however, above spoken of, is connected in general with three semicircular canals, of a similar structure, and furnishing more space for the distribution of the auditory nerve; and the earthy pieces, within the liquid contained in this bag, have begun to assume the appearance of regular bones. Still, in most fishes all these parts are buried within the skull, and send no process to the surface; in some of the cartilaginous tribes alone this bag being prolonged to the upper and back part of

head, where the blind termination of it is covered by the common integuments of the body. One fish alone—the Lepidoleprus Trachyrynchus—presents any appearance of a canal, proceeding from the surface to meet the internal parts, as in all animals above the rank of reptiles. But the extreme simplicity of the auditory apparatus in fishes and other aquatic animals, is precisely what we should have looked for in beings destined to hear through the medium of water; the vibrations of which, being so much more powerful than those of air, would render the complicated apparatus, requisite in terrestrial animals, in them superfluous.

Accordingly, it is in reptiles that we meet with, for the first time, more or less constantly, not indeed a canal leading from the side of the head towards the ear—which none of them have—but one leading from the back of the pharynx, to form a cavity, interior to which all the parts already described are situated. This cavity is called the tympanum, and contains more or fewer distinct bones, moved by proper muscles, and serving to increase the impulse derived from the vibrations of the air, and to convey it to the internal parts, which now take the name of labyrinth. Some additions, also, are now made to this; for, besides the three semicircular canals, already described as branching from the common bag in one direction, there is now a second series of canals, of a very complicated structure, called cochlea, branching in another, and affording, of

course, still further space for the expansion of the auditory nerve. It is true these parts are not common to all reptiles; serpents, for instance, having no tympanum—although they have a small bone, analogous to those which, in other reptiles, are situated in this cavity, but which, in serpents, is lost in the muscles of the jaws—and none but some of the highest orders of lizards, as the crocodile, having a cochlea. The last named animal, moreover, makes the first approach to the well known appendage to the ear, technically called the pinna; being furnished with a kind of external flap, with which it closes the auditory apparatus at pleasure. It is in this way probably that the animal excludes too intense sounds when under water; but it appears that the greater number of amphibious animals are capable of adapting their auditory apparatus, at least partially, to the medium in which they are, by putting all the parts upon the stretch, by means of the muscles already spoken of, when in the air, so as to qualify them to receive slighter impressions, and by throwing them all into a state of relaxation when under water, so as to prevent them from being stunned by more powerful ones.

In birds at length we meet with constantly a short canal, leading from the side of the head, and meeting that coming from the pharynx, in the tympanum. They have but one bone in this cavity; and the general structure of the parts of their labyrinth is very similar to that of the higher orders of reptiles. Birds in general want a pro-

per pinna, its place being commonly supplied by a small tuft of feathers: the owl, however, has something very similar to this part as found in mammiferous animals.

The auditory apparatus of the mammalia is in general little more than a greater developement of the same parts as are found in birds. The bones within their tympanum are from two to six in number; and all have a pinna except the cetaceous tribes—in which it would have been superfluous, from the vibrations of water being too strong to require to be collected by this means—and some others, which either dwell much in the water, as the shrew, or burrow under ground, as the mole, in which, for an obvious reason, it is still less called for. The shrew, however, is provided with a kind of flap, like that of the crocodile, the principal use of which seems to be, so far from increasing the intensity of the impression, to diminish it when the animal is under water. The great size of the pinna in some quadrupeds, and the frequency and rapidity with which they move it in any direction, are familiar to every body; and may well account, in conjunction with the complicated and delicate structure of the internal parts of the ear, for the extremely acute hearing which they enjoy, and which is so necessary, in many instances, to their security. Hence, a frequent and rapid motion of the ears is, in all animals, with justice regarded as indicative of a timid disposition.

With respect to taste, I have very little to say in this place, having already described the organs chiefly instrumental to this function, when speaking of those by which food is received and transmitted to the stomach. Whatever we may think of the three sensations already spoken of, taste is certainly, not only in the lower, but in all tribes of animals, merely a more delicate kind of touch; and is situated for the most part, not exclusively in the tongue, palate or any other individual organ, but in the whole interior of the mouth.

Although, therefore, in many animals, as the snail, cuttle and fishes in general, as well as in some individuals of the superior classes, the tongue is hard and cartilaginous, and apparently very little adapted to this function: nay, although it is, as in the flying-fish and gar-pike, altogether wanting, we have no reason to believe that they are destitute of taste; and the same thing may be said of the numerous animals in which the tongue is covered, more or less perfectly with prickles, or even with feathers, like the toucan, or scales like one kind of bat, which must in a great measure obviate the contact with it of sapid substances. The immediate instrument of taste seems to be certain pointed projections, called papillæ, with which the whole membrane lining the mouth is more or less abundantly furnished; and that organ will be of course in all animals the principal seat of this function, on which these papillæ are most copious. In the greater number of animals

it is unquestionably the tongue, which is, in some, as the bee and humming-bird, rolled into a sucking tube, and an organ, therefore, not only of taste, but of imbibition ; and, accordingly, when the lips take the same form, as in the wared whelk, and various kinds of fly, we may presume they are an organ, not only of imbibition, but of taste. Acuteness of taste seems to be much promoted by a copious flow of saliva, by which the sapid particles are dissolved ; and it may be presumed, therefore, that it is much greater in the herbivorous, than in the carnivorous birds and quadrupeds, as indeed the necessity which the former are under, but from which the latter are exempt, of distinguishing wholesome from deleterious herbs, would seem to require. Carnivorous animals, on the other hand, are directed to their food principally by the smell ; and how much they excel those which are herbivorous in this function has been already noticed.

The organ of touch—the most general of the sensations, and of which all the rest are perhaps only varieties—is, collectively speaking, the whole surface of the bodies of animals ; although it is, in each, much more delicate in certain parts of this surface than in others, owing to the greater number of papillæ with which they are furnished, and which are generally the immediate instrument, as well of touch as of taste. The common integuments of the bodies of animals in general consist principally of the scarf-skin or cuticle, a

substance immediately below this called corpus mucosum, of which the nails and hairs are merely modifications, and the true skin or cutis, the seat of the papillæ in question; and there are few animals, even of the lowest tribes, which have not all these envelopes in one form or another. In the armed polype indeed, the sea-blubber, the slug, the earth-worm, and many similar animals, the cuticle takes the form of mere mucilage; while in the corallines, on the other hand, it assumes that of a calcareous mass, by which their bodies are invested. In others again, it is the corpus mucosum which gives them their earthy covering, a proper cuticle being found exterior to it, as in the sea-urchin, the star-fish, and all the testaceous tribes: the sharp prickles, also, on the shell of the sea-urchin, as well as the hairs of the earth-worm, and numerous other animals of this tribe, are merely modifications of the same substance. A proper cutis seems indeed to be wanting in the corallines, as well as in some other animals of quite the lowest orders; but in the testaceous tribes, as the oyster, the cloak is probably a modification of this part, and it is accordingly upon this, or some corresponding organ, that the tentacula, or immediate instruments of touch, are commonly met with. The perspiration from the surface seems to bear the same relation to touch as the saliva bears to taste; and there are, therefore, few animals which do not perspire in one form or another. In some of these tribes, as the sea-blubber, the perspired

matter is said to be luminous; and it is to this cause that the sparkling appearance of the sea by night in some places has been attributed.

In insects, the cuticle is always membranous; while it is the corpus mucosum which constitutes their horny or calcareous sheaths, and forms, also, in some, as spiders, flies, gnats, bees and butterflies, the fine hairs, feathers or scales, with which they are in certain parts invested. The proper cutis again is below this, constituting, in the lobster, for example, its membranous pellicle. This part is, however, so completely defended, for the most part, from the contact of external substances, that to most insects are given in addition antennæ, palpi, cirrhi, &c. called, in general, feelers, situated commonly about the mouth, and the chief seat, in them, of the function of touch.

The cuticle is membranous also in fishes, and immediately invests their scales, as well as the bristles of the stickleback, the tubercles of the sturgeon, &c., all which are formed by the corpus mucosum. Under this is the cutis; but it is often so well defended from external impressions, that to many of these animals, as well as to insects in general, nature has given cirrhi, or other analogous organs, as an immediate instrument of touch.

In reptiles the cuticle is either membranous, or, as in the frog, consists merely of mucilage, as it does in many worms already noticed. The corpus mucosum in these animals, assumes the

form either of a soft viscid substance as in frogs, of a horny shield as in tortoises, or of scales as in serpents and most lizards: some of the latter, however, as the crocodile and alligator, have it again in the form of hard plates, like the shields of tortoises. It is of the corpus mucosum also, that the claws of such reptiles as have them are constituted. The proper cutis is situated under this; and as the papillæ of this organ are most numerous about the soles of the feet, we must conceive that it is in this part principally that the touch of reptiles is resident.

The perspiration of reptiles is in general very copious; that of the salamander, for example, being so much so, as to extinguish flame, and thus to have given rise to the fable of its being capable of living in the fire. In some, as the toad, the perspired matter is of a poisonous quality; and in one kind of lizard it is so acrid as to blister the fingers.

In birds, the cuticle is again membranous; while the corpus mucosum assumes the form upon the mandibles, of a bill; upon the body in general, of feathers; upon the legs, of scales; and at the extremity of the toes, of claws. Under this is the cutis, which, abounding in papillæ, most in general, below the bill, particularly in the swan, goose and duck, may be presumed to render this organ the most sensible of external impressions.

In mammiferous animals, the membranous cuticle covers a corpus mucosum, generally of a soft viscid consistence, but in some few animals

of this class, as the rhinoceros, armadillo, scaly ant-eater, &c., assuming the form of hard plates, like those of the crocodile and alligator. It is of the corpus mucosum, also, that are constituted, in some few, as the duck-billed animal, a perfect bill; and, in the greater number, the hair, fur, wool, bristles, quills, &c., with some one or other of which their bodies are covered; as well as the horns, claws, hoofs, &c., with which many of them are furnished. The cutis, lying under this, is, in all, the organ of touch; which is most acute in the duck-billed animal, upon the bill; in the carnivorous tribes, at the root of the whiskers; in those with moveable snouts, as the mole, hog and elephant, upon this organ; in the bat, upon the membrane between their fingers, commonly called their wings; and in most of the Glires, as the squirrel, as well as in apes and other animals of this description, at the tips of the fingers; since it is in these organs respectively that the papillæ are most abundant. It is unnecessary to point out how admirably this corresponds with the habits of each of these animals: and the delicacy of touch which some of them enjoy in the organs in question is wonderful—an elephant, for example, being able to distinguish by the tip of its trunk, between the most minute objects, and a bat being capable, though deprived of the use of its eyes and ears, to direct its rapid flight through the most intricate places, the touch alone of its membranous wings sufficiently apprising it of the

contiguity of objects, and thus enabling it to avoid them.

The last subject for consideration at present is Loco-motion, or the function by which animals are enabled to shift from place to place. A very great number of quite the lowest orders of animals, as the zoophytes and corallines, remain in general permanently fixed to the substances to which they are found attached, like plants to the soil; and even some which shift their place, like the sea-blubber, seem to do so, not actively, but by the motions of the waves in which they live. The great majority, however, even of these tribes employ various means of progression, and each presents something interesting in its manner of effecting this. The motions of the snail are familiar to every body. They are effected by that part of the animal called its foot; which is nothing more than numerous muscular fibres of a jelly-like consistence, and quite colourless, as in all invertebral animals, situated on the lower surface of the strong membrane in which all the entrails are contained, and attached, also, to the shell, so that the foot can be either protruded or retracted at pleasure. Its progression is by a vermicular motion; and it attaches itself to the surface along which it glides, partly by forming a vacuum with the sole of the foot, in the manner of a sucker, and partly by a viscid mucilage secreted by the part. The loco-motion of the

mussel, as well as of other bivalve mollusca, is effected in a similar manner, the animal protruding the foot beyond the shell, and crawling along upon it; and it is furnished, also, with the same kind of adhesive mucilage, for the purpose, not only of steadying its steps during motion, but also, as drawn out into threads under the name of byssus, of preventing it, when at rest, from being washed away from the rocks to which it attaches itself by the tides. The motions of the shell, in these animals, are perhaps instrumental, as I have already observed, rather to respiration than to loco-motion; although, according to Home, the oyster is capable of projecting itself to a considerable distance, by suddenly closing its shell. This is effected by one strong muscle near the hinge. Of the other animals of this class, some, like the cuttle, move by a kind of arms, attached to their head; others, like the glaucus, by their gills or fins; and others, lastly, like the sea-mouse, by a kind of rudimentary legs. The arms of the cuttle—eight or ten in number, according to the species—are provided with numerous tubercular suckers, by which the animal attaches itself at pleasure; but they are capable of acting at times with so much force, as to enable it to spring to some height out of the water. The gills of the glaucus again act merely in the capacity of oars; as do the hairs or bristles which invest the whole body of the sea-mouse, each of which, being set in motion by proper muscles, constitutes, as it were, a rude

prototype of a proper leg; they have no joints, however—a total want of which, in all animals of this class, constitutes one of their most characteristic distinctions.

The motions of insects are much more perfect than those of any of the preceding animals, and perhaps also of any others. In the centipede, indeed, the legs are not much more perfect than the bristles of the sea-mouse; but in the cray-fish, scorpion, spider, &c., they are very highly organized, and moved by regular muscles, arising from the calcareous or horny covering of the animal, which is accordingly often represented as its skeleton. This reputed skeleton, however, is, as I have already shown, only a modification of the corpus mucosum. All winged insects have six legs of this description, two attached to their corslet, and four to their thorax; and many of them have, either in the course of their legs, or at their extremity, numerous suckers, by which they form a vacuum every time the legs come in contact with any surface; and it is in this way that flies are enabled to crawl upon a perpendicular plane, however smooth—a mirror, for example—or even to walk along the ceiling of a room, being thus held up by the pressure of the atmosphere. It is, of course, unnecessary to say, that, under the exhausted receiver of an air-pump, they remain always on the floor of the instrument. The structure of these suckers is strikingly beautiful, considering their excessive minuteness—they are best seen in a kind of

beetle, a kind of bug, and the common blue-bottle. The power with which some insects move their legs is perfectly stupendous—the grasshopper, for instance, being capable of leaping many hundred times its own length, and the flea, of carrying a weight eighty or a hundred times heavier than itself. The strength of a strong man, on the contrary, has been computed by M. Desaguliers rarely to exceed four hundred pounds, or less than three times and a half his own weight; while that of a weak man is not above one hundred and twenty-five pounds, or less than his own weight. But the most remarkable organs of loco-motion in insects is their wings, which now, for the first time, show themselves in the scale of animals: of these, however, it is sufficient to say, at present, that they are moved by muscles of immense power, and that the velocity with which they are moved, is at least as remarkable as the force. The advantage to winged insects of the numerous air-tubes with which their whole bodies are intersected, has been already insisted upon; and serves beautifully to illustrate the harmony of design which characterises their whole economy.

Most fishes effect loco-motion principally by their fins; and of these they employ chiefly the pectoral and ventral pairs, which are strictly analogous to the upper and lower extremities of the superior tribes of animals, while the dorsal, caudal, and anal fins are, as it were, a kind of supernumerary organs. The two first named pairs

are attached respectively to a kind of shoulder-bone and hip-bone; and they are all moved by very strong muscles, which take a lamellar structure, but are still in general colourless—those, however, about the head of the salmon are of a red colour, and all those of the lamprey of a dark grey. Some tribes effect their progression by the motions, not of a fin, but of the spine—for example, the lamprey—which has neither pectoral nor ventral fins, and which seems to move in its natural element, the mud, entirely by the lateral flexion of its spine, which it at first draws into an S-like curve, and then shoots forwards the anterior portion. The same is the case, also, with the eel, when it creeps on land. Others again, as most of the flat fishes, which, like the lamprey, have neither pectoral nor ventral fins, use their tails principally in making progress in the water. The bodies of fishes are of very nearly the same specific gravity as the water in which they live, owing to the great quantity of fat which most of them contain; so that little effort is required to keep them at any given height, and their descent or ascent in the water is comparatively easy, the latter being further promoted by the faculty they possess, and to which I have elsewhere alluded, of filling their air-bladder at pleasure with air. When they attach themselves to rocks, it is by means of suckers like those of the cuttle; and when they leap from the surface of the water, it is by the sudden and forcible extension of their bodies after a strong

flexion, the elasticity of the water giving them thus the force of a projectile. Some fishes, lastly, as the flying kinds, are capable of using their long fins in the air, almost in the manner of the wings of birds, while some birds, on the other hand, dive and swim under the water almost as well as fishes; and a most beautiful sight is thus sometimes presented to mariners, of whole flocks of these two classes of animals alternately exchanging, as it were, their natural elements, the one with the other.

Reptiles in general make progress on land either exclusively by crawling, as tortoises and most lizards, or by either crawling or leaping as frogs; and the manner in which some of them, as lizards, are enabled to move up a perpendicular surface is still by a species of suction, the soles of their feet being provided with a series of soft plaits, which being drawn up at pleasure, produce the requisite vacuum. The muscles of these animals are, in general, of a redder colour than those of fishes; but they are, for the most part, still without tendons. Some reptiles again, as serpents, advance, like eels on land, chiefly by the motions of their spine; but they assist them by those of their ribs—which are, in them, organs rather of loco-motion than of respiration—being at intervals raised, or advanced like legs, and the rest of the body afterwards drawn towards them. Some lizards also, as the salamander, seem to advance at least as much by the motions of their spine, as by those of their legs; while others, as the fly-

ing lizard, use their ribs as organs of progression, not, however, like serpents, in the manner of legs, but in the manner of wings. The flying lizard is, however, a very harmless little being, and quite unworthy to have given origin to the dreadful stories of fiery dragons so common in nursery books. In the water, most reptiles use their legs almost in the same way as fishes in general do their fins; and some of them, as turtles, keep themselves afloat by a collection of air below their dorsal shield. The motions of a frog in the water, furnish a very good lesson to man of the manner in which he should use his limbs in a similar situation.

We have seen that fishes in general move but in the water, but that some are capable of advancing either on land or in the air; and, that reptiles in general move equally well either in the water or on land, but that some of them also are capable of flying; and the same is the case with birds. When on land, their progression is effected by either walking or hopping on their posterior extremities only, birds alone being the only proper bipeds among the lower animals; and they are enabled to keep themselves erect without effort, since their centre of gravity corresponds to the region where the anterior extremities are attached, owing, in most birds, to the legs being directed forwards, and the toes more elongated, but, in some, as the penguin and the puffin, to the trunk of the body being placed almost vertically. The manner also in which they

support themselves while asleep upon a perch, furnishes a beautiful example of adaptation of the most simple means to a necessary end; the whole mechanism consists in making the muscles which close the claws, pass in such a manner over the joints of the knee and heel, that upon the mere bending of their joints, they are put upon the stretch without even the consciousness of the animal. The muscles of birds are of a redder colour and firmer consistence than those of any other animals, and they are furnished in general with very strong tendons, which, as age advances, are very liable, particularly in the aquatic and gallinaceous birds, to become converted into bone. Birds are enabled to float in water owing to their specific gravity being in general less than that of this fluid, and hence they displace only as much of it as is equal to their own weight, according to the well known hydrostatical law; and they move along its surface by the action of their webbed feet, the swan appearing to use its wings, in addition, almost in the manner of sails. But the characteristic organ of lo-co-motion in birds, as in insects, is their wings, corresponding in their more essential parts, as well with the pectoral fins of fishes, as with the fore legs of reptiles and quadrupeds, and the arms of man. The motions of these are effected by a mass of muscles weighing more than all the rest of the muscular system of the animal put together, and arising from a breast-bone of a larger size than is to be met with in any other class of ani-

mals: the immense power thus acquired being no more than is necessary to enable them at once to support themselves in the air, and to move through it with such astonishing velocity. The former they effect by continually renewing the column of air below them—and which must be displaced, in order to allow of their falling to the ground—more rapidly than this displacement can take place, and the latter by using their wings in the manner of oars, while the tail, at the same time, serves them for a rudder; and so powerful is the impulse acquired in this way, that they not unfrequently travel at the rate of sixty or one hundred miles in an hour, or over a distance equal to that between the capitals of Scotland and England, in the same time that an ordinary stage-coach takes to travel about thirty miles. The advantage to birds, as well as to insects, of the great quantity of air which prevades their bodies—even their bones—has been already pointed out; and this obvious subserviency of one part of their structure to the rest, irresistably inculcates the truth that one Master-hand has regulated the whole.

The loco-motion of mammiferous animals need not detain us long. The cetaceous tribes alone move constantly in the water; and this they effect almost in the same manner as fishes, taking care, however, to keep the summit of the head—which is often loaded with a kind of fat for this purpose—always above the surface, in order not to interfere with respiration. It is from the

comparative facility with which quadrupeds keep their heads above water, that they in general swim better than man; the legs in them being the heaviest part, while in man the head is so. Very few quadrupeds are capable of moving through the air—the bat, the flying squirrel, and some species of lemar being among these; and this they effect, not like the flying fishes and birds, by their anterior extremities alone, nor like the flying lizard, by their ribs, but by wing-like membranes extended between their anterior and posterior extremities, the motions of both which are requisite to call them into action.—Quadrupeds, in general, use their upper limbs only in conjunction with their lower in the act of progression, but some few, as squirrels, apes, &c., use them also, in the same manner as we use our arms; and when such is the case, they are furnished, like man, with a collar-bone, which they are in general destitute of; the two bones of their fore arm, also, are moveable upon each other; whereas they are otherwise consolidated together. In standing, they use in general all the four legs; and, as the centre of gravity is thus preserved without any effort, they easily sleep in this posture; some few, however, as the kangaroo, the jerboa, &c., rest on the hinder legs alone; the centre of gravity falling, in them, almost perpendicularly: but such are accustomed to use their strong tails almost like a third leg, not only in steadying themselves, but in assisting them in leaping. The chief muscles

going from the trunk of the body to the limbs of quadrupeds, are inserted so low down the limb, as almost to conceal the parts which correspond respectively to that part of the arm of man which is above the elbow, and to the thigh; and this low insertion of the muscles, giving them thus the advantage of so much longer a lever, readily accounts for the much greater power with which they act. Their manner of performing on a flat surface the walk, the amble, the trot and the gallop, needs not to be particularly described.—In climbing, some few, like the walruss, seem to attach themselves, like lizards, by forming a vacuum with the soles of their feet; but the majority use their claws for this purpose, and these in some tribes, for example sloths and ant-eaters, are so long, that they are almost incapable of walking on a horizontal plane. In conclusion, I may observe that, so nicely and admirably are all the organs of loco-motion in quadrupeds adapted to each other, that an anatomist, from the inspection of any one bone out of the two or three hundred which compose the skeleton, is enabled to infer the general form and relations of all the rest, as well as of the ligaments which connect, and the muscles which move them.—Nor is this all: for, so intimately does the structure of this shell, as it were, of the body correspond with that of the internal parts, that, from this one bone he may almost give a description of every organ of the animal—of its propensities, and of its habits! Can this correspondence be

the work of a blind chance? or does it imply a unity of design, an extent of benevolence, and a vastness of power, indicative of a ruling Providence—the great Architect alike of the star of the firmament, and of the mite which plays in the sunbeam—whose hand is traced equally in the immensities of magnitude and of minuteness—the Almighty Father of the universe, and of every thing which astounds and delights us in its construction?

CHAPTER VI.

THE REVOLUTION OF THE SEASONS.

THE wisdom, and power, and beneficence of an Almighty Creator, is in nothing more discernible among His lower works, than in the revolution of the seasons. In these the heavens and the earth operate on each other; "the rolling year" is full of God: in its course, all His attributes are called into operation, in so far as they regard us, His dependent creatures; and, while the awakening spring sends forth the snow-drop and the crocus to speak of His benignity and love, the snows, and the rains, and the hurricanes of winter, remind us of the vengeance which has been threatened against sin, and the power of his avenging arm!

I have already, in speaking of the adaptations of the external world to our wants and necessities, alluded to the harmonious succession of the seasons; and now, as I intend the following observations to be more of a popular than a scientific kind, my mention of the influences which regulate them, will be merely such as are necessary for a bare comprehension of the subject. Suffice it, therefore, to say, that the motion of

the sun round the earth is performed in an orbit, the plane of which being extended to the heavens, traces among the constellations of the fixed stars, a great circle of the sphere called the ecliptic, and which is inclined to the equator. The opposite points at which these circles intersect each other are called the equinoctial points. The points of the ecliptic most remote from the equator are called the solsticial points. When the earth is in one of these points, the apparent place of the sun is in the opposite one ; it being evident, that the apparent path of the sun will be the same as that which is really traced by the earth, and that they will always be in opposite positions to each other.

By the solsticial and equinoctial points, the ecliptic is divided into four equal parts ; and the intervals of time employed by the sun to describe them constitutes the four seasons. In our latitudes, spring is the period occupied by the sun in passing from the equinoctial point, which it meets in ascending, called the vernal equinox—to the northern solsticial point called the summer soltice. Summer is the designation of the period which it takes in passing from the summer soltice to the autumnal equinox, or point of the equator it touches in descending. Its passage from that point to the winter soltice constitutes autumn, and from thence to the vernal equinox is winter.

It might naturally have been supposed, since the sun's apparent path in the heavens is the

great circle of a sphere, and since this circle is equally divided into four parts, by the four points, which I have just mentioned as determining the seasons, that the four seasons should have been equal in duration. Centuries, however, before the Christian era, it had been discovered that this was not the case, a circumstance which it would be difficult to have presupposed, seeing that the circumference of a circle is, by the very nature of the curve, similarly situated in every part, with respect to the centre. The fact is, that the summer months are about eight days longer than the winter ones, and an investigation of these apparent phenomena ultimately led to the figure of the earth's orbit, which is now well known to be an ellipse—a curve, which possesses a variety of curious properties, and which being formed by a certain intersection of a cone, has been called a conic section. Thus it is that the eliptic circle, being the perspective representation of the ellipse on the concave surface of the heavens, must of course exhibit all the irregularities of the original, and we thus see the reason of the seasons being unequal in duration. In considering the effects of the apparent motion of the sun, it is usual to designate the nearest approach of the earth as *perigee*, and its farthest distance as *apogee*; and from what I have just said, it is evident that the summer and winter months can never be equally divided, but in the particular case of the coincidence of the solar perigee, with one or other of the equinoxes.

Such are the only principles, which I think it at all necessary for my present purpose to allude to, regarding the general nature and effect of the motion of the earth in its eliptic orbit, as constituting the revolution of the seasons. It is more consonant to my plan, by an examination of the changes on the earth's surface, to shew the wisdom, power and beneficence of the Creator, and thus from the contemplation of nature to lead the thoughts up to nature's God.

When we regard the vegetables and animals distributed over the earth's surface, we find that each species is particularly destined to a certain kind of climate, be that arctic, temperate or torrid. In that we find it in its greatest perfection —in others, which differ from it, in a degenerate form, and in some, absent and totally unknown. It is curious, however, to observe, that since elevation above the sea produces nearly the same effect on climate, as distance from the equator, that the mountains of the torrid zone being covered with eternal snow, are capable of producing, at different points of elevation, almost all the plants of all the different regions. From the greater heat and humidity between the tropics, nature is there more varied, vigorous and luxuriant; and, gradually as we recede from this zone, the plants diminish in number, size and beauty, till, on the shores and islands of the arctic sea, they either entirely disappear amid the wilderness of frost and desolation, or are reduced to a few stunted shrubs and mosses, which scarce-

ly do more than indicate the vitality of the earth's surface. Man, whom God created as its master, is, as I have before observed, the only organized being which exists in all regions where it is possible for life to derive nutriment, including the fish of the sea, the fowls of the air, the animals which roam in the wood and field, or the vegetables and fruits which luxuriate in its various regions. Indeed, so widely is man diffused, that Spitzbergen and Nova Zembla in the north, with the Falkland islands, New South Shetland, Kergueland's Land, and a few other tracts in the Southern Ocean, are the only extensive countries which are not known to possess inhabitants. That climate and situation modify the character of animated beings is not to be denied, but none have either raised the brutes to the dignity of rational intelligence, or enabled them to dispute with man the claim to rank as the lord of the creation. Man is far from being the slave of climate or the seasons; and, "it is only in the apprehension of ignorance and inexperience," as Professor Gillespie eloquently observes, "that his condition, however remotely or approximately situated with regard to the sun, appears wholly miserable: for whilst the inferior animals degenerate, or perish under a protracted or distant removal from their native clime and soil, man alone is found, and is, by an arrangement of Divine wisdom, fitted and framed, not only to live, but to enjoy life every where. And thus, as there is not a latitude which does not manifest to its

inhabitants the wisdom and benevolence of Him who hath made these admirable adjustments; so there is not a variety of seasons, even under the same climate, which, whether from 'the light breaking forth as the morning,' or from 'the pavilions of darkness,' accords not with this tone of universal gratulation."

Although in our climate February most frequently presents a wild and wintry aspect, yet it may be regarded in milder seasons as the decided commencement of that spring which is about to renovate nature. It is now that the woodlark renews its note, and the thrush retunes his throat to melody. The rook revisits its breeding tree, and makes choice of its nest for the approaching summer. Towards its end the fruit buds commence swelling on the trees. The lauristinus has not yet lost its early blossoms, and the china-rose in full beauty betrays not its transplantation from an eastern climate. But what was indicated in February, becomes in March reality. Its visible heralds appear with their tabards of many colours. The snowdrop, the crocus and the primrose, are succeeded by the hyacinth and the tulip, shewing above the ground the vesture which is to surround their many-tinted blossoms. Every tree and shrub speak of the renovation of nature, and to the observant eye the hand of Omnipresence is visible in the clearing sky—the lengthened day—the more genial sun—the opening bud—the expanding leaf—the bloom which

is in itself beauty—and the blossom which promises fruit.

As March advances, so doth the train of Flora increase; the earlier flowers are succeeded by the daffodil, the yellow auriculas, the coltsfoot with its pink, its golden and its silvery stars, the cowslip with its rose-coloured blossoms, and, if Favonius invites, the violet which poets sing and all eyes love. The hyacinth stately and rich, and the narcissus delicately languid put on their blossoms, and on the garden wall the peach and nectarine vie with them in beauty. In the meadow, the ash puts forth her grey buds, and the catkins of the hazel and the willow tell that the life within is no longer dormant. The hawthorn greens all over with fresh young leaflets, and the daisy of the field shews itself in that modest beauty, which has drawn strains that can never die from the poetic pens of Chaucer, Wordsworth, Burns, Delta and Montgomery.

It is now also that the trouts begin to rise in the stream, and the water-fly may be seen skimming along the surface of the secluded pool. On fine and warm days the brimstone-winged butterfly issues from the wood to enjoy the noon-day sunshine; the ewe drops its lamb; the sparrow builds its nest; and in the twilight, when Hesperus glimmers over the southern hill, the bat comes forth on restless wing to spend an hour in dalliance with evening, till scared to his ivy-bed by the deepening shadows of the night.

Anon Spring deepens into Summer ; the sun ascends higher in the heaven ; the day lengthens and the heat strengthens ; nature is robed in luxuriance of verdure ; the storm-vexed ocean sleeps like a lake ; the air murmurs with exulting insects ; and, bush and brake, as " hymning their great God," send forth the voice of melody.

But as June melts into July, the music of the groves makes a pause, or is left almost to the wren and a few tiny companions, the yellow-hammer being among the last of the minstrels which forsakes the twig to take to its nest, where now lie its eggs, figured with irregular scratches, as if artificially marked with a pen.

Even in this successive nidification of the singing birds, the wonderful regulations of Supreme wisdom are visible. Not only is provision made for the continuance of the harmony which enlivens glen and grove, the sunny glade and the gloomy forest, but a certainty is given of the parent birds procuring food adapted for their young. Thus the yellow-hammer, which I may adduce in illustration, takes so late to the building of its nest, because its young are nourished principally on those seeds which nature profusely affords at this period, and not earlier ; while the rook, actuated by a similar instinct, hatches in April, when the turning up of the soil affords abundance of grubs and worms, which could not be found at a later season, and when this source fails, the common chafer affords a long supply. The blackbirds and thrushes breed early for the same rea-

son. It is only the fool, who hath said in his heart, "there is no God," who can mistake this guiding and guardian instinct for mere chance.

To paint a summer day were a work of supererogation—its glories are embalmed in every heart capable of feeling, and who possesses one, which has not expanded as the eye surveyed fields laden with grain yellowing to the harvest—trees bending with fruits, whose perfume filled the glowing air—flower-beds like the rainbow in their hues—the bright blue sky and its golden clouds shewing in bold relief the wooded hills—and, over all, the mighty sun, like the visible eye of God, shedding life, and lustre, and happiness over the broad bosom of creation! And when afternoon hath melted into evening, and from behind the western hill the purpling glories of the daylight fade, hue after hue, typifying in a grand and mighty scale the changes witnessed in the dying dolphin's back, what meditative heart does not throb in accordance with the lines of the poet?

The evening star illumines the blue south,
Twinkling in loveliness. O! holy star,
Thou bright dispenser of the twilight dews,
Thou herald of night's glowing galaxy,
And harbinger of social bliss! how oft,
Amid the twilights of departed years,
Resting beside the river's mirror clear,
On trunk of mossy oak, with eyes upturned
To thee in admiration have I sate
Dreaming sweet dreams, till earth-born turbulence
Was all forgot; and thinking that in thee,
Far from the rudeness of this jarring world,
There must be realms of quiet happiness.

Delta.

When chaos existed in its great original winter, God said "let there be lights in the firmament of heaven, to divide the day from the night; and let them be for signs, and for seasons, and for days, and years." Then the first spring advanced over the desolation of matter, and the earth was warmed into life by the beams of the genial sun. Divine goodness walked forth unveiled; the bare soil became pasture; the snowdrop, and the crocus, and the primrose, and all the earlier flowers put forth their blossoms in succession to the light of morning; the fig tree and the vine gave promise of fruitfulness; birds and insects filled the wide air with their songs and murmurs; and the face of creation under the sun, and the west wind, and the floating cloud, and the refreshing dew, put on an aspect of general cheerfulness. Earth, air, and water were peopled with inhabitants, their faculties and their duration established by a fixed law, and nature proceeded in her annual round of growth and increase, and maturity and decay. When regarding this season, well may we exclaim with Alison—"if there is an instinct which leads us now into the scenery of nature, it is not only to amuse us with a transitory pleasure, but to teach us just and exalted conceptions of Him that made us. In no hours of existence are the traces of His love so powerfully marked upon nature, as in the present. It is in a peculiar manner the season of happiness. The vegetable world is bursting into life, and waving its hues,

and spreading its fragrance around the habitations of man. 'The desert,' even, 'and the solitary places are glad, and the wilderness springs and blossoms as the rose.' The animal world is marked by still deeper characters of happiness. Myriads of seen, and far greater myriads of unseen beings, are now rising from every element into life, and enjoying their new-born existence, and hailing with inarticulate voice the Power that gave them birth. The late desert of existence is now filling with animation, and every element around us is pregnant with life and prodigal of joy. Is there a time in which we can better learn the goodness of the universal God? Is it not wise in us to go abroad into nature, and to associate His name with every thing that at this season delights the eye and gratifies the heart? And is there any image under which it is so useful for us to figure Him who inhabiteth eternity, as under that of the Father of the creation; as having called every thing into existence for His pleasure; in communicating happiness; and as, in these moments, listening with placid ear, to every articulate voice that speaks gratitude, and to every inarticulate voice that testifies joy."

Of all the vicissitudes of the year, none is more tranquilly magnificent than the moonlight of autumn. With what a deep delight the lover of nature, resting on the brow of a green hill, beholds the broad silver moon emerging from the sea, to reign over the night, and shedding over

the forests and the fields, slumbering in their luxuriance, a glory which is enchantment. The blackbird has sung his requiem to departed day, and all the air is still, as if our world of turmoil were one of repose. The stream winds like a thread of silver through the vale; and if, haply, a rural church-yard be near, with its spire like a finger pointing to heaven, and its mossy tombstones, and its venerable yew, the soul is solemnized and softened; the vanities and the littleness of our daily pursuits appear in their true light; and man's immortal destiny seems almost evident without the aid of revelation, from the very magnificence of the earthly habitation which God has created for his abode.

All poets downward from Homer to Coleridge and Wilson, have hymned the praises of the moon: its pervading influence has by none been so sweetly figured as by Keats:—

> "Oh moon! old boughs lisp forth a holier din
> The while they feel thy airy fellowship;
> Thou dost bless every where, with silver lip
> Kissing dead things to life. The sleeping kine
> Couched in thy brightness dream of fields divine;
> Innumerable mountains rise, and rise
> Ambitious for the hallowing of thine eyes;
> And yet thy benediction passeth not
> One obscure hiding-place, one little spot
> Where pleasure may be sent; the nestled wren
> Has thy fair face within its tranquil ken,
> And from beneath a sheltering leaf
> Takes glimpses of thee."

But if nature's tranquil magnificence be so imposing in the moonlight of autumn, not less

striking is the tempestuous array of the thunder-storm at that season. The clouds congregate; the sun withdraws his beams; the winds retire into their chambers; the waters put on an inky hue; the birds hush their songs in the woodlands; the flocks bleat as if in dismay in the meadows; and, on the mountain side, the lowing of the cattle is wild and desolate. Anon a transient breeze stirs the grass, and the leaves quiver for a moment as if convulsedly; and now, a few big drops of rain patter amid the boughs, heralding the lightning, which is the parent of thunder. How sublime that peal which echoes and re-echoes through the immensity of space, proclaiming the power of the Almighty, and portending to man—the breaker of his commandments—how limitless may be the vengeance, which his disobedience is incurring! the hills look dark in the distance; the ocean rolls in mountain-billows to the shore; the clouds open their windows, and pour down rain and hail upon the earth; till, having spent its wrath, the tempest passes over, and again the glad sun, darting a beam through the rent battalia of the clouds, calls forth the rainbow to span the east, and to proclaim to man, that the anger of God will not only not abide always, but that he has only to repent, that he may be forgiven!

When the sickle has levelled the aureate ripeness of the fields; when the orchard has shed its mellow fruits; when the garden flowers fade; and when the forest trees wear a varied livery,

the wild cry of the partridge is heard at eventide, and the shortening day, and the declining sun, proclaim that the reign of winter is at hand. How pleasing at this season is the twinkling of the evening star! how melancholy are the meditations of him, who walks abroad to meditate, like Isaac, at eventide!

Oh fading bowers!
Oh shortening days and nights of dreary length!
How emblematic of the fate of man
Are ye, and of his fast declining strength,
His chequered lot, frail life, and fleeting span!
Thousands have fall'n since joyous spring began
Its smiling course,—say, shall the next be ours?

Now at morn and eve, if the weather be clear, the earth is covered with hoar-frost. Vegetation is every where passing rapidly into decay. The oak, the beech and the hornbeam yet partially retain their leaves, while those of almost all the other trees are shrivelled by the blast, or have returned to their parent earth. It is now that the evergreen trees, the firs, and the pines, and the hollies, which the splendid summer foliage had thrown into shade, remain to claim our attention and regard. And how coldly, serenely beautiful it is as the shades of night clear away before the uprise of the faint low sun, and the robin hopping on the window-sill comes with its sweet voice to solicit crumbs, to gaze abroad and behold the earth enveloped in a winding-sheet of snow, while the traveller passes by with soundless feet, and the eaves are armed with crystal-

line icicles. Turn to the lake, and lo! the wizard frost hath enchanted the water, on whose surface the young are loud at their pastime—the waves are chained in their flow, and the cataract hangs over the rock in suspended beauty, reflecting back the red light of the eastern sun.

Yes! if spring in its budding leaf, and opening flower, and favonian breeze, indicates the Omnipresent kindness of the Creator, and summer and autumn attest the prodigality of His bounteous love, nature seated on her throne of storms preaches to us of His power amid the desolation of winter, and calls on us, in the march of the whirlwind and the roar of the angry flood, to abstract our thoughts from the passing things of earth, and form an acquaintance with the dark and lonesome grave!

In the preceding remarks on a few of the external aspects of the seasons, I have but skirted the outlines of a voluminous and inviting subject, the numerous subdivisions of which would each require a much longer chapter for itself, and afford curious and abundant matter for the illustration of that wisdom which regulates alike the great and little things of the universe.

Innumerable, indeed, and irresistible are the arguments, which from a survey of the seasons alone, must take hold of every thinking mind, in attestation of the existence of an All-wise and Omnipresent Creator. When we regard the internal functions of plants, we find a complete cycle, which corresponds exactly to the duration

of the year. Spring is required for the ascent of the sap in the fruit trees; summer and autumn ripen their produce; and the cold of winter is necessary for hardening the shoots, which have been produced by the heat of the sun. "If the wheat-ear," says an eloquent writer, "were to remain exposed to the sun of a six month's summer, the grain would be reduced to chaff. If it were green during a spring of similar length, it would never come to maturity. Either our vegetables are suited to our year, or our year to them. In either case we see a law of mutual adaptation, which demonstrates the necessity of previous design." The invariable regularity with which the earth performs its annual revolution is demonstrative of Divine love; for, were not this the case, seed-time and harvest would fall into confusion, and all our calculations of time, and our dependence for direction from celestial phenomena would be vain and abortive. So would it be with the alternation of day and night, were the duration of these not immutably fixed also; the vegetable kingdom even would be convulsed; the marigold, which as Shakspeare says,

> "Goes to bed with the sun,
> And with him rises weeping,"

the hawkweed, the day-lily, and the dandelion and others, from which Linnæus attempted to construct a natural clock, from their opening and closing at certain hours, would have all their

wonderful mechanism destroyed, did the sun rise and set at uncertain intervals. So would it be with man. A period of sleep once in the twenty-four hours is necessary to restore the bodily energies, which have been exhausted by a day's activity; and unless his corporeal frame were quite altered from what we now know it to be, the recurrence of night only three times in the week, instead of once in the twenty-four hours, would not only diminish the duration of life instead of extending it, but be a drag on his activity, instead of propelling it to exertion.

Finally, then, the revolution of the seasons is an inexhaustible theme for praise, if we regard the goodness of God, and of wonder, if we contemplate the stupendous machinery which is in constant and unerring operation for its government and regulation. Well has it been said by the royal lyrist of Jerusalem, that "day unto day uttereth speech, and night unto night teacheth wisdom." Taken individually, each of the seasons has its peculiar delights. When the storm of winter beats against the pane, the social circle feel more intensely the comforts of the domestic hearth, and the student poring over his books, finds it the most genial time for holding communication with the recorded thoughts of by-past ages; and few minds are so destitute of sensibility as not to expand with grateful emotion, as earth spreads forth the exhaustless variety of spring. In the luxuriance of summer the

beneficence of the Supreme Being is every where visible, and the autumn

"Spreads a liberal feast for all that live."

But while all on earth is passing and perishing, God remains the same; and on all he hath impressed the signet of mutability and change, to tell man that his home here, also, is but a transient abode; while, at the same time, the regular laws which govern the universe, may shew him that there is behind all an Essence unchangeable and unchanged, without beginning of days or end of years.

CHAPTER VII.

DISTRIBUTION AND MIGRATION OF ANIMALS.

The distribution of animals over the globe is a curious subject, and one involving many difficulties, which philosophers have not the means of fully elucidating. In each of the different regions of the earth, there are not only plants, but also different animals, which appear to be natural, as it were, to the soil. In many instances, these differences involve whole families of animals, which are confined to certain districts; but in the majority of cases, they extend only to certain species, each of which has its own particular habitat. Nor is this peculiarity confined to one particular class of animals, but extends equally throughout all the divisions of quadrupeds, birds, reptiles, fishes and insects. Man alone, of all animals, is the inhabitant of every region of the earth which has hitherto been explored. With respect to quadrupeds, some, as the lion, elephant, camel, hippopotamus, tiger, panther, leopard, hyæna, giraffe, &c., are found only in hot climates; while the white bear, the seal, and many others, are met with only in the colder regions near the poles. Of birds, also, the cocka-

toos, parrots, birds of paradise, humming birds, and other splendid varieties, are proper to the torrid regions ; while the eagle, the eider-duck, the albatross, and numerous other tribes, are confined to districts more or less cold. The majority of reptiles again, and other cold-blooded animals are met with only or chiefly in hot climates ; and it is of these, accordingly, that the deadly rattle-snake and cobra-de-capello, and the formidable crocodile and alligator, are inhabitants. In like manner many of the most remarkable fishes, as the flying-fish, the electrical fish, &c., occur only in tropical waters ; while some few only, as the cod, inhabit the frigid waters of the north. Of insects, lastly, the hordes of splendid butterflies and fire-flies, of mosquitoes and white ants, which inhabit hot districts, are known to every body ; while cold districts, on the contrary, are comparatively destitute of them.

But it is not climate alone which produces these differences ; for, of all the animals which I have above enumerated, scarcely any one is the inhabitant indiscriminately of any hot or of any cold climate, but each has its own specific locality, in which alone it arrives at perfection. Nay, many districts appear to have their own peculiar tribes of animals almost independently of the climate, as is particularly the case with regard to America. When America was first discovered, no quadrupeds corresponding to our horses were found there ; neither was our spe-

cies of sheep nor of oxen; no lions roam over its torrid plains; nor is the elephant, or camel, or hippopotamus of the old world there a denizen. On the contrary, we meet with there the zama, the tapir, and numerous other quadrupeds, to which the old world affords nothing similar. In New Holland again, we have the kangaroo, a marsupial animal, but quite different from the American opossum, and that singular anomaly the ornithoryncus, which in structure and habits partakes both of the bird and quadruped. So likewise the birds and insects of the American continent are almost totally distinct from those common to the old world, however well adapted we might suppose those winged creatures, to transport themselves into every clime and region.

We find further, that islands are in general more thinly inhabited than the continents which they nearly adjourn—though in these cases the animals are of the same species, for the most part, as those of the neighbouring mainland. In islands far removed from continents, however, the species of animals are generally distinct and peculiar. Of this circumstance New Holland presents us with numerous examples, as well as Java, Sumatra, and the islands in the Chinese seas.

Now, the question has been started, has the colonization of the earth proceeded from one central point; or have there been various such points, from which the numerous tribes of ani-

mals have radiated? and, although we may in all humility re-echo the interrogation—"where wast thou when I laid the foundations of the earth! declare, if thou hast understanding!" yet revelation teaches us, that all created beings were inhabitants originally of the same district; and again, that all animals were collected a second time into one spot at the deluge. This, then, we are bound to believe; but how are these facts reconcilable with those which have been above stated—that each tribe of animals requires a peculiar temperature, and that each is now a denizen of certain districts alone? In my opinion, they are easily so, if we keep in mind first, that every variety of temperature is procurable by differences in the elevation, under precisely the same latitude; and, secondly, that there are no assignable limits to the power which animals possess of migrating from one district to another. With respect to the former position, it is very well known, that in Quito, one of the mountains of the Andes, within a space of twenty miles, all the various temperatures of the globe are found. At the base is the torrid zone and the plants and animals of that region; farther up, is a temperate climate; and still higher, is the frozen atmosphere with the soil and products of arctic countries. A similar remark may be made with respect to the Alps; and so decided are the different climates on the declivity of the Peak of Teneriffe, that the whole has been divided into five distinct zones, called respectively—accord-

ing to the characteristic vegetable productions of each—the region of vines, of laurels, of pines, of brooms, and of grapes.

Now, if we picture to ourselves the first inhabited district of the earth to have been a long range of elevated continent, surrounded with islands, we can easily understand how all kinds of animals, as well as vegetables, may at one time have lived, and moved, and had their being on almost the same spot; and, independently of the subsequent migrations of the former, if we call to mind that great changes, whether occurring at once or at successive periods, may have broken up and separated this primeval continent, with its accompanying islands, we shall not be at a loss to imagine how a dispersion, and separation, and a distinct grouping of the animal kingdom may have taken place. But to aid this dispersion of animals, we have in addition their migratory propensities. A great proportion of animated beings have the power of loco-motion; some, as quadrupeds, as I have shewn in another place, in a considerable degree, and others, as birds, fishes and insects, to an extent which may embrace the whole circuit of the globe. It is true, we cannot ascribe to quadrupeds the power of traversing oceans by their own unassisted resources, in the same manner as the winged tribes are known to do, and thus of colonizing the new world from the old, provided the relations between the two had always been the same as at present. But there is every reason

to believe that such is not the case; and even though it had been, there is nothing absurd in the supposition, that stragglers may have been occasionally wafted from such parts of the one as were not very remote from the other, in a kind of floating forest, which had been overthrown by the tempest, and borne by sweeping rivers—such as is still the case with the Mississippi—into the ocean.

In general, the great exciting cause of migration among animals is the search of food. Thus, among quadrupeds, wild deer move from one part of the country to another in particular seasons, as is exemplified in the rein-deer of Lapland and the northern parts of America, in order that they may procure in perfection the necessary supply of their aliment. So also the winged denizens of the air fly from region to region, as the insects on which they subsist are called in succession by the march of the seasons into existence; and it is with a similar object that the fishes of the ocean perform their long periodical voyages.

If it is asked, what teaches these animals thus to undertake far journeyings at particular times; I can only reply by demanding in return, what teaches the orb on which we have our being to revolve around the sun as a centre? what teaches the heart of animals to pulsate, or the sap to ascend, as regularly as spring returns, into the minute vessels of the oak of the forest? It is to us inexplicable, otherwise than by referring

it to some particular and inherent law, imposed upon them by their Creator. One thing, however, is evident, that these journeys are not commenced or pursued as man would pursue them —that they are the result of intuitive impulse, not of thought, reason and deliberation.

A bird of the migrating kind, even when confined for a series of years within the close barriers of a cage, has been observed, when the periodical seasons of its natural journeyings has arrived, to become restless and feverish, and to strive with incessant and unwearied efforts to escape from its prison; whereas, had reason been its privilege, a moment's reflection would have shewn it that its attempts were vain and futile. When we can explain the nature of the impulse which actuates the beaver to construct its hut, the bird to build its nest, and the spider, the silk-worm and the bee, respectively to form their web, their cocoon and their comb—and all this as easily and faultlessly the first time of undertaking it, as at any subsequent period—we may attempt an explanation of that which prompts animals, under certain conditions, to migrate; but until we can do the former, I apprehend we must be content to acquiesce in the latter as an ultimate fact.

But granting this impulse,—many have been so astonished at the prodigious journies of migrating birds, as almost to doubt whether any such be really performed. These sceptics have had recourse to the idea that swallows, for ex-

ample, either dived below the water, or burrowed in the earth, and that woodcocks and rails concealed themselves in holes at the periods when they were supposed to migrate. But if we reflect upon the swiftness of these birds, propelling them at the rate of fifty to one hundred miles in an hour—if we consider that they take advantage of favourable winds—that they skirt in their flight the borders of land and rest occasionally their tired wings, the space travelled over by them will not appear so vast and impracticable. Besides, few migratory animals undertake, in the present day, very long journeys; we have no interchange, at present, of American and European birds by this process, and seldom any of those peculiar to remote islands.

With respect, lastly, to fishes and insects, the migrations of many of these animals are hardly less remarkable than those of birds, and abundantly adequate to explain their general dispersion over the globe, even without admitting—which is, nevertheless, doubtless the case—that all tribes of these, and many other animals, are liable to be conveyed, in either their perfect or their embryo state, by migratory birds, from one district to another. And, indeed, the journeyings of insects and fishes are not, at least in the present day, very stupendous. Locusts confine their migrations within comparatively limited bounds; and although some kinds of fish, as the herring, traverse a vast space of a northern sea,

it is doubtful whether they ever extend into the southern hemisphere.

How limited, then, are the journeyings of even the most buoyant and the fleetest of creatures, compared to the roamings of man over every region of the habitable globe! Nevertheless, they may have been quite sufficient, in conjunction with the other causes already assigned, to effect the distribution of animals from a single spot, and a single pair of each species, over the whole earth; and to fix each particular species in the locality and temperature best suited to its habits and nature. The opposite opinion, that a successive creation of animals has occurred, and may still be going on, is as contrary to well established facts as to revelation. Tribes of animals which once existed may have become extinct; but there is no reason to believe that any new tribes ever start up; on the contrary, nature, amid all her diversities of tribes, approaching and blending into each other by almost imperceptible shades, is ever careful to prevent a multiplication of species. Thus, animals in a state of nature keep distinct—the lion never mates with the tigress, or the elephant with the rhinoceros; the smallest wren is faithful to the partner of its own kind, and the insignificant insect selects its fellow for a mate; and though occasionally, from unnatural connections, some kinds of mixed monsters are produced, they are happily, by a beneficent law of nature, incapable of propaga-

ting their disgusting race. Had it been otherwise, the earth would have soon swarmed with beings more shapeless and revolting than any fabled of Circe or the loathed Sycorax; and neither grace, nor beauty, nor fitness, nor proportion would have characterised, as they do, the works of God.

CHAPTER VIII.

THE CULTIVATION AND ACCLIMATION OF PLANTS.

I do not intend to enter, in this place, upon a lengthened introduction to the study of botany; I prefer rather to point out a few of its fundamental truths; and, by endeavouring to call the attention to the sweets this pursuit scatters so abundantly upon those who follow it, to induce the reader to learn from other writers the principles upon which this interesting study is founded. It has been asserted, that botany consumes time without affording a sufficient recompense. That such, however, is not the case, is evident from its intimate connection with the sciences of dietetics, pharmacy, &c.; and surely whatever adds to our knowledge, or to our pleasures; whatever has a tendency to call forth our better sentiments, or to elevate our minds to the contemplation of the Deity, through the medium of His works, is deserving the attention and the study of mankind. No pursuit is more congenial to the human mind than the study of nature; and no one can pursue this most engaging of all her

walks, gaze upon the beauty and the simplicity of the forms displayed, the delicacy and the splendour of the colours, and feast upon the sweetness of the perfume, without feeling an awe and admiration of that Omnipotent source from whence these pleasures are derived. The study of the vegetable kingdom leads the botanist to spots most richly decked with nature's beauties; to view her stores unrolled, and converse with her charms; to him the heath-clad moor, the lofty mountain and the wild morass, are not the dreary barren wastes they seem to others; there undisturbed but by the flitting bird, or hum of insect sporting in the noon-tide air, he finds food for contemplation, replete with entertainment and instruction. What is a more perfect emblem of purity than a mountain plant, the flowers of which blushing unseen and glistening with the morning dew, shiver in the breeze; and does it not forcibly impress upon our minds, that the same hand which reared this lonely plant—destined, perhaps, to perish unobserved, yet so perfect in all its parts, and evincing such consummate skill,—that the same watchful power which hath been exerted for it, cannot be forgetful of man? Sentiments such as these, excited in the breast of Mungo Park by the sight of a humble flower in the middle of the desert, changed his melancholy forebodings respecting the fate awaiting him, into a cheerful pious dependance upon that all-powerful arm, which in the dreary waste, far from the abodes of man, had raised and pro-

tected with a Father's care, that lonely flower. Behold, too, the simple wall-flower!

Cheerful 'midst Desolation's sadness—thou—
Fair flower, art wont to grace the mouldering pile,
And brightly bloom o'er Ruin, like a smile
Reposing calm on Age's furrowed brow.
Sweet monitor! an emblem sure I see
Of virtue, and of virtue's power in thee.

For though thou cheerest the dull ruin's gloom,
Still when thou'rt found upon the gay parterre,
There art thou sweetest—fairest of the fair;—
So virtue, while it robs of dread the tomb,
Shines in the crown that youth and beauty wear,
Brightest of all the gems that glitter there.

And also view the passion-flower—how delicate and how fair! A plant of matchless elegance, it surely is a meet emblem of that we hold most dear:—

Its tender shoots, fostered with care, extend
Far in festooned luxuriance,
Its drooping flowers, too, blend,
Sweet mixture! modesty and loveliness;
But more—when closely viewed, this flower appears
To bear the sacred mark of sacred tears,
Adding to the plant's beauty—holiness!

How like this flower can woman be; so fair!
So beautiful! too delicate her mind
Would seem, the world's rude with'ring frosts to bear
Without some guardian's help, round whom to bind
Its tendrils in pure trusting confidence.
When rightly trained her blossoms bloom, they shine
In more than beauty's lustre; they combine
With earthly charms, celestial innocence,
Breathing of sacred things; yet, like that flower, alone
To those who view her near, her holiness is known.

Still after all, perchance, it is but very childish-

ness that would weave fancies with flowers, and borrow from their hues a colour for our thoughts; but if it be, it surely is a weakness at which philosophy would rather smile than frown. Lord Bacon says, that the study of botany, and the pleasures to be found in the garden, "are the greatest refreshment to the spirits of man;" and, perhaps, it was among his shady walks, or in rambling over hills and meadows, that he felt his mind purified from its grosser and more worldly affections,—perhaps it was there he forgot that love of power and of place that made him though "the greatest," yet "the meanest of mankind." Sir Isaac Newton was ardently attached to this pursuit. Pope was a celebrated gardener, and often mentions the delight he felt in flowers; and Lord Peterborough, after all his victories in Spain, did not forget his rustic enjoyments.—Addison says, in the Spectator, "I look upon the pleasures which we take in a garden as one of the most innocent delights of human life. A garden was the habitation of our first parents before their fall. It is naturally apt to fill the mind with calmness and tranquillity, and to lay all its turbulent passions at rest. It gives us a great insight into the contrivance and wisdom of Providence, and suggests innumerable subjects for meditation. I cannot but think the very complacency and satisfaction which a man takes in these works of nature, to be a laudable, if not a virtuous habit of mind." Though all have not a garden to retire to, still all possess the fields;

and in the words of Bigland, "the earth is but an immense garden, laid out and planted by the hand of the Deity; the lofty mountains and the waving forests are its terraces and its groves, and fertile fields and flowery meadows form its beautiful parterres."

The endless variety and diversity of form, and colour, and structure displayed in the vegetable kingdom, are evidently intended to excite the attention of man: and well would it be for him if he oftener followed that natural inclination—that innate principle implanted within him, but blunted and made obtuse by more worldly considerations—which would lead him to the contemplation of the works of creation.

As I before stated, I have no intention at present to enter upon the first principles of botany—so many popular and cheap treatises on the subject are to be met with, that it would be useless here to do so: all that I propose undertaking at present is, to draw the attention of the reader to the effects of culture upon plants, and to point out to him how clearly an acquaintance with the vegetable kingdom, shows that the curse of an angry and justly offended God, pronounced in the beginning of the world, has been hitherto incessantly executed. In the third chapter of Genesis we find "cursed is the ground for thy sake; in sorrow shalt thou eat of it all the days of thy life: thorns also and thistles shall it bring forth to thee." It must have struck the most unobserving beholder, that, although the earth

brings forth most abundantly thorns, thistles, and every other noxious weed, without the slightest care of man, yet such is not the case with those plants upon which we depend for our very existence; and that its strength and powers are even exhausted by a few crops of the latter, and which it soon fails to produce. The same is apparent with our fruit trees; if left to themselves, their very fruitfulness will destroy them; they throw up such innumerable shoots that light and air become excluded, and the tree dies, or at least decays for want of proper nourishment.

I cannot conceive a more satisfactory proof of the truth of the inspired nature of the scriptures, than the evident fulfilment, in these our days, of sentences pronounced against sinful man thousands of years anterior to them; and where can we find a more convincing fact than the one now before us; or where more palpably perceive the ancient curse of God actively prevailing against us? It was decreed that man "in the sweat of his face should eat bread;" and where, let me ask, without it will the earth yield her increase? I will not enter upon any argument concerning what would have been the state of the earth in relation to her productions, had not this curse been pronounced; suffice it for us to know, that the curse has prevailed, seeking not to intrude our poor and insignificant ideas upon the nature of things hidden from us. We know that in most plants, from the lowly weed to the towering and majestic tree, comparatively few of the seeds produced

ever ripen, or take on that state necessary for germination or for food; there seems to be some power of nature which prevents plants from putting forth all the fruits contained in them—some great, Almighty influence which checks them in their growth, and prevents their progress to perfect developement. To the unbeliever this fact is inexplicable, and it must remain obscure to all who see not in it the never forgetful hand of God. It is only by the labour of man that the earth will produce her fruits; and it is only by his incessant toil that she will yield her strength, and bring forth so abundantly as to supply our wants and necessities. How incessantly does the agriculturist till his ground! how constantly must he drive his plough and enrich the soil with foreign substances, which should he neglect to do, what is the result? Does it not return to the state in which by Adam's sin it was reduced, and bring forth nought but thorns and thistles?

The amazing fertility of all species of the thistle renders them proper instruments for the fulfilment of this curse against mankind. There is one species which bears about one hundred heads, each containing from three to four hundred seeds. Suppose we say that this thistle produces eighty heads, and that each contains only three hundred seeds, the first crop from these would amount to twenty-four thousand. Let these be sown, and the crop produced from them will be five hundred aud seventy-six mil-

lions. Sow these, and their produce will be *thirteen billions, eight hundred and twenty-four thousand millions;* and a single crop from these (which is only the third year's growth), would amount to *three hundred and thirty-one thousand, seven hundred and seventy-six billions;* while the fourth year's progeny would be more than sufficient to stock not only the surface of the whole globe, but of all the planets in the solar system, so that no other plant could possibly grow, allowing but the space of one square foot for each thistle!

The histories of some of our most useful and profitable vegetable productions serve abundantly to establish the fact, that it is by the sweat of his brow alone that man has succeeded in bringing them to their present state. The effects of cultivation are indeed wonderful; its acts upon plants, by bringing forth the powers inherent in them; there is no cause so constantly and so powerfully operating in bringing them to perfection, and there is none, the influence of which is so multiplied, and so considerable in relieving them from the curse pronounced against them for our sin. Culture changes the very nature and habits of plants; not only are the organs increased in beauty and in size, but by its agency they are even altered; plants, which in their natural condition are biennial, are by cultivation reduced to annuals, from the increased rapidity with which they are hurried on, in the performance of their several functions. The reverse of

this position also holds true; for, if we produce a delay in the period at which annual plants flower, with many we succeed in converting them into biennials. Wheat will furnish us with a familiar example. In its natural state it is but an annual plant, pushing from the seed in spring, flowering in summer, ripening its grain in autumn, and dying with the approach of winter,—the whole period of its existence scarcely exceeding six months.

From the mode in which it is generally cultivated, however, its life is often protracted to twelve, sometimes to thirteen months, being frequently sown in September and not reaped until the October of the following year. Numerous other individuals are improved in their natural qualities by cultivation. All the varieties of the apple, for example, owe their origin to the sour and unpalatable crab, which no one would now recognize in the flavour and beauty of our choice specimens. Cultivation has multiplied the varieties of the pear almost to infinity, and produced them all from one worthless species. The peach, in its wild state, in Media, is poisonous; but cultivated in the plains of Ispahan and Egypt, it becomes one of the most delicious of fruits. But in few plants are the effects of cultivation more apparent than in the Brassica tribe. However extravagant it may appear, all the varieties of red and white cabbage, savoys, brussels-sprouts, winter greens, cauliflowers and broccolis, have sprung from one poor and insignificant-looking

weed—the brassica oleracea, common in many parts of the kingdom. The grape and the fig are not indigenous to France, but by cultivation have become naturalized there; in like manner, the orange in Italy, and the cherry among us.

But no example can better demonstrate the extraordinary power of the efforts of man in overcoming, by the effects of culture, the peculiar habits in which individuals of the vegetable kingdom have naturally been placed, and habituating them to other circumstance, than the Siberian crab. This tree, when first introduced into Britain from Siberia, put forth its leaves and flowers at the first indication of the approach of spring. While other trees yet wore the garb of winter, this was gaily decked in all the beauties of May. In its native country the interval between winter and summer is but short; there is scarcely any spring, and that at once bursts forth into a glorious summer. There it had not been accustomed to the second winter so common with us, or to the sudden checks vegetation so frequently receives during our deceitful spring; and it broke from a state of torpor and inactivity with the earliest retreat of winter. The consequences were such as might have been anticipated,—with the first frost it received a check—its shoots, unable to withstand the shock, perished. But now view this tree, so ornamental to our gardens and our shrubberies; by cultivation—the results of the labour of man—its habits have

been changed; it does not so hastily put confidence in our treacherous spring; and, advancing more cautiously, escapes destruction.

An instance somewhat analogous, illustrative of the consequences of the labour of man, and shewing how great may be its results, is detailed by Sir Joseph Banks, who thought that many plants might, by cultivation, become inured to a climate, soil and situation, foreign to their original habits: and certainly many circumstances, received as truths by the generality of horticulturists and vegetable physiologists, seem to warrant our acceptance of his theory.

"In the year 1791," says Sir Joseph, in the first volume of the Transactions of the London Horticultural Society, "some seeds of the zizania aquatica were procured from Canada, and sown in a pond at Spring-grove, near Hounslow; they grew and produced strong plants which ripened their seeds. These seeds vegetated in the succeeding spring; but the plants they produced were weak, slender, not half so tall as those of the first generation, and grew in the shallowest water only; the seeds of these plants produced others the next year, sensibly stronger than their parents of the second year. In this manner the plants proceeded, springing up every year from the seeds of the preceding one, every year becoming visibly stronger and larger, and rising from deeper parts of the pond, till the last year, 1804, when several of the plants were six

feet in height, and the whole pond was in every part covered with them as thick as wheat grows on a well managed soil."

"Here," adds Sir Joseph, "we have an experiment which proves, that an annual plant, scarcely able to endure the ungenial summer of England, has become, in fourteen generations, as strong and as vigorous as our indigenous plants, and as perfect, in all its parts, as in its native climate;" and certainly it is unquestionable that it is to the influence of culture, in varying and improving the natural qualities of vegetables, that we owe many of the luxuries of the table and dessert,—nay, man could scarcely have been civilized but for this power of culture over the vegetable kingdom. The present state of society depends for its existence on the production of grain; but grain in its natural state is not worth producing. Wheat, before it has been subjected to the influence of cultivation, is an insignificant and worthless seed; yet to this same seed, when improved by culture, and to others as trifling, when subjected to the same process, do we owe all the comforts of civilized life. Culture has on the brute creation analogous effects; the colour, shape, size, flavour and very habits of plants, are altered by cultivation, and precisely the same effects are produced upon animals. Man himself varies in colour, size and habit, according to the circumstances in which he is placed; and, indeed, it seems a law throughout the whole animate creation, that each individual shall become

habituated to such circumstances. But the most extraordinary effect of cultivation, and the one to which we owe most of our flowers and fruits, is the change it produces on the natural habits of plants; delicate exotics may be made to grow in the open air in this country; vegetables truly aquatic may be made to grow in dry ground, and plants may be habituated to circumstances of a very different description from those to which they were accustomed in a state of nature.

Much difference of opinion, it is true, has existed as to the positive truth of the foregoing statement, but daily experience points out the important consequences of cultivation in this respect; and as there can be little doubt that many reputedly conservatory and hot-house plants are, in reality, quite able to bear the severity of our climate, it becomes a question of much importance what will, and what will not, prosper in it, not only as involving a most interesting subject, but as the solution of this question may greatly tend to increase our agricultural wealth. And, indeed, when we reflect that climate itself is not stationary, but that cultivation is every day considerably improving it, it is by no means utopian to suppose we shall in time be possessed of many of the choicest productions of tropical countries.

It would certainly be a matter of moment—nay, one of the greatest importance, to discover that, although the original plant first imported to a colder climate is unable to resist its severity,

yet its seeds produce hardier plants, and these again still more so, till individuals are obtained perfectly naturalized and acclimated; and it is very certain that numerous plants that were formerly cultivated in the hot-house and conservatory, are now found capable of withstanding our severest frosts, thriving and bearing fruit in the open air. "Thus we see," says Dr. M'Culloch, "everywhere flourishing in the borders, the most luxuriant plants of heliotrope, fuchsia, verbena triphylla, geraniums and numerous others, replacing the wretched starved specimens formerly nursed with the greatest anxiety in the green-houses." Whether this be owing to their having gradually become capable of bearing our climate, or to their having been from their first introduction into the country, able to do so, is still a matter of doubt and uncertainty. Much may be said, and many facts produced, on both sides of the question. Perhaps we are too apt to judge of the hardiness of plants, and their capability of bearing the severity of our climate, from the nature of that from which they come; and thus seldom thinking of giving them a trial, many individuals which no one would have planted but in a very high temperature, have only accidentally been discovered to be perfectly able to flourish in the open air; and because others, on being removed from the house, have perished, it was immediately supposed that they could not vegetate but in a warmer atmosphere. But even the common

roses which are kept in our dining and drawing rooms, being thus rendered more susceptible of cold, often perish on their sudden exposure to it; whereas, had they been gradually habituated to its impression, they would, without injury, have borne it. Phenomena analogous to these, are constantly observed in the animal kingdom; and, therefore, we should not be discouraged, nor relinquish our attempts, should we fail in our early endeavours to acclimate plants.

It has been recommended, that plants to be tried should be put out in the beginning of summer, turned out of the pots into poor and very dry soil, and sheltered from the east and north winds. From the hot-house, they should be removed to the green-house, then to the open frame, and finally to the border,—covered up the first winter, and even the second, should it not prove mild.

In general, plants bear to be removed from cold to heat better than from heat to cold; hence, a greater proportion of the natives of this country thrive in the south of Europe, than can bear transportation thence to us. This facility of emigration is by no means universal; nor in every case, where it is practicable, is it accomplished without difficulty and inconvenience.—There are many plants which will not bear a warmer climate: thus, wheat and barley will not grow within the Tropics, while, with numerous individuals, the contrary is the case,—they will bear a removal to a colder climate, where the

frosts of winter are often accompanied with snow, which shelters the plant from the inclemency of the atmosphere until the return of spring; and thus many trees and plants may be acclimated by planting them among natural coppice, where they are, in a great measure, protected from the weather. Every one on entering a wood in winter, must have been struck with the difference of the temperature from that of the open field, and may have seen there several plants, such as the cowslip, violet and snowdrop, in full flower, while, in the neighbouring gardens, their leaves have scarcely made their appearance. It is well known that many rare plants, which had disappeared with the cutting down of a wood, have re-appeared when it has again grown up. "One reason why the American plants grow so luxuriantly at Fonthill Abbey," says a writer in the Gardener's Magazine, "is, that they were introduced among native underwood, interspersed among bushes of hazel, dogwood, &c., and sheltered by firs, oaks and other timber trees." A shrubbery is, therefore, to be considered as the best place for acclimating exotics, whether trees or herbs, and more especially if the soil be dry, and the shrubs chiefly deciduous; for it should not be forgotten, that many believe that a coppice wood of evergreens is always colder than one of deciduous bushes, owing to the leaves presenting a greater surface for evaporation. Groves of evergreen trees, on the other hand, especially of the pine and fir tribe,

present a warmer climate beneath them than groves of deciduous trees; because the former, from the closer texture of their exterior surface, reflect back more completely the heat radiated from the ground below. The more any plant is shaded in winter, the less danger it will be in of suffering from frost. For, when a plant, or water, is so situated as to be overtopped by trees, the radiation of caloric is in a great measure checked; and thus in such situations, we may often observe water unfrozen, and plants unhurt by the cold, and many retaining their leaves, when others of the same species, at a short distance, but unshaded, lose their leaves and suffer considerably.

Mr. John Street, the gardener at Beil, who has succeeded in acclimating numerous plants, states, in the Transactions of the London Horticultural Society, that he has found poor, dry and shallow soils and declivities, to be best adapted for preserving plants through the winter season. The quicker the superabundant fluid passes away from the roots the better. From every observation, it appears that those plants which have the least sap in winter, or the sap of which is of a resinous or oily nature, suffer least from cold. It would be foreign to my purpose to enter into a discussion of the cause of this, or of the theories that have been built upon it; suffice it at present to say, that it has been supposed that the principal cause of the destruction of tender plants in winter, is owing to the vessels being burst by the freezing of the sap. In choosing plants, there-

fore, for our experiments, we should attend to their organization: annuals bear exposure better than perennials; and those abounding in sap, having a spongy porous wood and much pith, succeed with difficulty. It seems advantageous that the plants to be tried should be deprived of moisture as much as possible. Mr. Street found, that, when planted above drains, several reputed green-house species have flourished most luxuriantly. Plants do not suffer from frost in dry situations, nearly so much as they do in moist, or when an excess of rain is followed by a severe frost. The reason is evident,—in moist situations, part only of the moisture is evaporated during the day, the rest remaining to be converted into ice by the cold of the ensuing night. This icy covering increases the cold, till the vital principle, and resistance given by the formation of the bark to the entrance of cold, are overcome; the sap is frozen, and the vessels burst by the expansive force of freezing.

Plants, in a warm climate, perspire more than in a cold one; so that in the one they require much, and in the other little moisture. The inhabitants of a hot-house must be abundantly supplied with water to replace the constant evaporation that is going on; but, on being transplanted to a colder climate, they should have a drier soil; and, when from a colder to a warmer, a moister one, than in their native station.

It has hitherto been regarded almost an axiom, that no plant produced by cuttings ever becomes

hardier than the parent tree, through whatever succession of progeny thus formed. Dr. M'Culloch doubts the truth of this assertion, and Mr. Street has found that "plants obtained from cuttings are hardier than seedlings; the roots of the former seem to possess more ability to resist severe weather;"—his experience is very considerable, and his opinions merit our attention. Mr. Street always plants cuttings, if they are well rooted, in preference to seedlings. The vine is almost always propagated by cuttings, and but few will assert that grapes are not more frequently ripened in the open air now than formerly.

I have alluded above to the acclimation of the zizania aquatica, or Canadian rice; and, upon the same principle, numerous productions of other climes are now cultivated in our open fields, and may in time be applied to useful and profitable purposes. The phormium tenax, or New Zealand hemp, now employed for producing the strongest cordage used in the navy, particularly on the New Holland station, has long grown in the open air in the counties of Waterford, Cork, Limerick, Louth, Wicklow, and Dublin. During a period of thirty years, it has only suffered once or twice in the extremities of the leaves, from the most severe frosts. Six leaves give an ounce of dried fibres, which it is calculated will exceed per acre the produce of either flax or hemp. It may be observed, however, that the separation of these fibres from the matter of

the leaf is not at present well understood. Whether this plant may ever become an object of cultivation with us is very doubtful. Two plants, however, have succeeded well near Inverness; they require no shelter, growing in a very exposed situation. The specimens in the Royal Botanic Garden of Edinburgh are very vigorous, but have not flowered.

The tetragonia expansa again, or New Zealand spinage, was introduced from New Zealand by Sir Joseph Banks, in 1772, and treated as a green-house plant, but has lately been found to grow as freely as the kidney-bean, or nasturtium. As a summer spinage, it is as valuable as the orache, or even more so. Every gardener knows the trouble that attends the frequent sowing of the common spinage throughout the warm season of the year: without that trouble it is impossible to have it good, and, without the utmost care, it cannot always be obtained exactly as it is wished, from the rapidity with which the young plants run to seed. The New Zealand spinage, if watered, or raised on a rich soil, grows freely and produces leaves of the greatest succulency during the hottest weather. Anderson, one of its early cultivators, had only nine plants, from which he says, " I have been enabled to send in a gathering for the kitchen every other day since the middle of June, so that I consider a bed, with about twenty plants, quite sufficient to give a daily supply, if required, for a large table."

Near Exmouth, this invaluable addition to

our kitchen gardens has become quite a weed: wherever it has once grown, plants rise spontaneously.

I need not bring forward more examples of the power of cultivation. The practical advantages which it is calculated to insure, it is evident are considerable; while the moral truths which the study of vegetable physiology may inculcate upon the well regulated mind, are too apparent to require to be insisted upon.

CHAPTER IX.

GEOLOGY.

The modern study of geology, the history of which may be carried back as far as the beginning of the sixteenth century, was originally associated with a deep reverence for the inspired writings, which greatly modified the views of enquirers regarding this interesting subject, and which, being unhappily connected with the prejudices and misconceptions of a dark and superstitious age, led not unfrequently to the mystification of the science, and the retardation of its progress. In later times, however, and especially within the last half century, this study has fallen into the hands of men of sceptical minds, who, running into an opposite extreme, have not only rejected the erroneous views respecting scripture which misled former writers, but have boldly renounced all the information derived from this infallible source, and have freely indulged in speculations altogether irreconcilable with the Divine record. Indeed, it would appear, that there has of late been a studious attempt, not

only to disconnect geological discoveries with the truths of revelation, but even to place the former in contrast with the latter, and thus insidiously to undermine the great principles of our holy faith. Against this unhappy tendency I must enter my strongest protest. The evidence of revealed religion rests, indeed, on a separate ground altogether, but its foundations are immoveable, and, whatever it has clearly propounded as an article of faith, cannot but be true. Its *dicta* are facts on which we may securely reason, and which it is as unphilosophical as it is impious to reject. In saying this, however, it is not to be understood that we ought to overlook the obvious accommodations in the language of scripture to ordinary forms of speech—as when it is said that the sun and the moon stood still;—but the account of the creation, and of the flood, contained in the book of Genesis, is of a different kind, and as it cannot be renounced by the believer, neither can it be explained away. We may therefore rest assured, that no fact in the appearances of nature can really contradict that account; and it is highly satisfactory to think, that the more deeply the subject is investigated, the more remarkably do the discoveries of geology confirm the Mosaic record, when rightly understood, both with regard to time and to circumstances.

The real state of the question, however, seems to be but imperfectly appreciated, and it may be proper to say a very few words with the view of

relieving it from the mistakes of bigotry and ignorance on the one hand, and the misrepresentations of infidelity on the other.

In the first place, I must observe that there seems to be nothing in the scriptural account which militates against the supposition, that the *materials* of which our globe is composed existed long previously to the commencement of the Mosaic creation, or which even contradicts the opinion, that many races of living beings may have preceded that period. The very terms, indeed, in which the history of this latest creation is introduced, if they do not positively imply, do, at least, evidently leave room for the hypothesis. —"In the *beginning* God created the heavens and the earth," is the short but emphatic introduction to the sublime passage, intimating merely that matter is not eternal and self-existent, but that there was a period in the infinity of duration in which it had a "beginning," and was called out of nothing by the Divine *fiat*. Then follows a description of the state of the globe, immediately before the plastic hand of the Almighty was applied, at the commencement of our creation, to mould it into order and beauty;— "The earth was without form and void; and darkness was upon the face of the deep;" that is—the whole materials of this planet were at that time in a state of chaos. Of what took place during the period, whether long or short, between the first formation of these materials, and their appearance in this state of disruption and darkness, we

are not informed. So far as revelation is concerned, the whole previous history of the earth is left a total blank; but if any indications should appear to human research, leading to a belief in earlier forms of organized existence, the terms in which the revelation is couched, seem purposely so expressed as to favour that belief, and leave room for discovery.

Now, it is here precisely that researches and discoveries have been made. It has been found, that the matter of which the earth is composed bears marks of an antiquity much beyond that of the human race; and that, while every geological appearance confirms the truth of the Mosaic history, as regards the period when the organized existences which at present cover the earth received their origin, there are undeniable proofs of long and successive epochs before that period, in which plants and flowers, now totally unknown, adorned the face of nature, and rose to luxuriance under warmer suns—in which animals of different forms and species roamed the woods and forests, and in which the ocean rolled its billows, and the finny tribes found food and enjoyment, where now fertile fields wave with grain, and the lofty trees of the forest throw their boughs towards heaven, and man and beast tread the solid ground.

There are, therefore, two distinct periods of time to which the geologist has to direct his attention,—that which preceded the Mosaic creation, and that which is subsequent to it—and two

distinct series of phenomena, corresponding to these periods, each marked with its own peculiar character. In referring to the first of these periods, if we examine the order and stratification of the rocks we shall find various epochs, marked with a sufficient degree of precision, during which changes of the most extensive and important kind have taken place, and fresh deposits have been made, which have changed the aspect, and new modelled the face of the earth. We can even assign an order of time, as well as of other relations to these changes. First, in this order, we find granite, and other associated rocks, which have justly been called primitive, because, while they very often do rise above all others, they are seen with surprising uniformity to dip below them all, thus forming the solid foundation on which rests the whole matter constituting the crust of the globe. Next to these is discovered a series of rocks which has been named the transition deposit; because, while rocks of this class certainly rest immediately on the primitive, they have been supposed to form an intermediate step between this and what has acquired the distinctive appellation of the secondary formation. Next to the secondary succeeds the tertiary formation, which constitutes the newest of the deposits belonging to the first period of the world, and may be referred to the time immediately preceding the Mosaic creation.

This tertiary epoch must have ended in a violent catastrophe, occasioning an entire disrup-

tion of the old state of things, and a complete destruction of organized existences. The materials from which the Mosaic creation was produced were, as scripture informs us, in a state of chaos;—"the earth was without form and void;"—and such was the commixture of elements, that light could not penetrate the formless abyss. "Darkness was on the face of the deep." The organic remains, however, which are to be found embedded in the rocks of this first period, prove incontestably that the great Creator had not suffered the materials he had called into being to lie unoccupied. Plants and animals, of various forms and species, all of them differing from those which are now to be found on the earth, have left unequivocal traces of their existence; and, what is not less worthy of remark, during the countless ages of that primeval period, it appears that more than one series of organized beings have been created and annihilated.

There is something sublime in this discovery of the hand of Omnipotence busied in communicating life and joy to inhabitants of the earth at periods so exceedingly remote, and so far preceding the very existence of the human race; and it seems scarcely possible to enter on this field of enquiry without deep feelings of awe and reverence. To penetrate the gloom of chaos, and see the same Eternal Being, who has in this later creation given such unequivocal displays of his perfections in the history of man, manifesting

the very same perfections among more ancient races of beings, and by His providence governing other worlds, formed of the very same materials, and impressed with the same natural laws, is an employment calculated to fill the imagination and to elevate and enlarge the mind;—and it is deeply to be regretted, that the rash speculations, and contemptible views of human vanity, should ever have mingled with so high and sacred an enquiry.

It is not, however, my intention, in the present short sketch, to travel, farther than I have already done, beyond the bounds of the Mosaic creation, for proofs of that profound wisdom of which the world is full,—or to engage in a controversy with the infidel, as to the nature or extent of the geological indications at which I have glanced. What scripture so unequivocally avers is conceded on all hands—that man was the last formed of living beings; and it is even allowed that the other animals which now exist with him on the surface of the globe, belong entirely to his epoch, and are not to be found in the deposits of an earlier period. These concessions, which the infidel makes with reluctance, and not without various qualifications, I cannot but regard as a triumph to the cause of Christian truth; and as every day is bringing new facts to light, which are sweeping away the flimsy foundation on which his speculations rest, I confidently anticipate the time when those phenomena which, on a superficial view, appear the

most staggering, will be found to unite in confirming the faith of the doubtful, and giving additional confidence and satisfaction to those who already believe.

It will not easily be forgotten how eagerly the infidel has seized on the slightest appearances which seemed to militate against the truth of Divine inspiration, or how often and how signally his most formidable attacks have not only been foiled, but turned against himself. The fate of the Hindoo chronology, by which Bailly and Playfair so exultingly endeavoured to overthrow the chronology of the Bible, and the abortive attempts of Brydone, and other writers of his class, to assign an antiquity to the present surface of the earth far beyond the catastrophe of the flood, by their plausible but hollow speculations on the successive alternations of lava and earth in the volcanic regions, might well render the enemies of the sacred record more cautious, if experience could teach them wisdom.

Among the various testimonies which the recent labours of the geologist have borne to the truth of scripture history, there is probably none more remarkable than that which has been derived from the researches of Cuvier. That eminent philosopher, has demonstrated, from an accurate examination of the present state of the earth's surface, that it is of comparatively recent origin, and cannot have been of a date much earlier than that which Moses has assigned to the deluge. "I conclude," says he, "with M.

M. Deluc and Dolomieu, that if there be any fact well established in geology, it is this, that the surface of our globe has suffered a great and sudden revolution, the period of which cannot be dated farther back than five or six thousand years. This revolution has, on the one hand, ingulphed and caused to disappear the countries formerly inhabited by men, and the animal species at present best known; and on the other, has laid bare the bottom of the last ocean, thus converting its channel into the now habitable earth."

To enter into the scientific induction of particulars by which Cuvier arrives at this conclusion, would be inconsistent with my present plan; and I must content myself with stating, in a few words, the principles on which he proceeded, and some of the leading facts which he has successfully demonstrated.

In considering the general aspect of the globe, one of the first things which attract the attention of the geologist, is the existence of great undulations and inequalities in its surface,—a circumstance which is entirely inconsistent with the belief of the very remote antiquity of its present condition. There are so many agents constantly at work in breaking down, abrading and removing every thing elevated above the general level, that any series of ages approaching to infinity would certainly crumble to dust the hardest projecting rocks, cause the highest mountains to disappear, and reduce the whole earth to a uniform

and cheerless equality. The air decomposes matter subjected to its influence, the storm scatters it, the rain washes it away, the frost rends it asunder, rivers and overflowing torrents carry it to the valleys and the ocean; the formation of downs, the fall of forests, and the decay of vegetation, are continually altering the relative depth of the low grounds by their accumulations. Ages on ages might indeed pass away before these agents could produce their extreme effects—yet that their action is neither inconsiderable nor very slow, innumerable observations have rendered incontestable. Now, these are changes, the average extent of which can, in some degree, be estimated. It is quite possible, for example, to ascertain to what amount the deposits in the bottom of lakes, or at the mouth of rivers, actually accumulate in the course of a year, or series of years, and from the rate of accumulation thus acquired, to calculate back to the period when this accumulation first commenced—that is, to the period when the rivers began to flow, and the agents of change first exercised their influence. If many observations of this kind in various quarters of the earth be found nearly to coincide in their results, we are obviously carried back to an epoch at which the present state of the surface of the earth had its origin;—and if various *dissimilar* modes of calculation are found to coincide, the proof rises to demonstration. Now, this is in fact the remarkable conclusion to which Baron Cuvier, and

the other philosophers he mentions, have been brought by their researches. They discovered that a great variety of concurrent circumstances, founded on the principle I have now alluded to, fixed them down to a period at which the present surface of the world must have taken its form, agreeing, in no unequivocal manner, with the chronology of the inspired writings, as to the era of the deluge.

As an instance of the convincing manner in which these geologists reason on the subject, I select the following interesting extract from Cuvier's Theory of the Earth, which contains only one of many appropriate illustrations. "M. De Praney, a learned member of the Institute, inspector-general of bridges and roads, has communicated to me some observations which are of the greatest importance, as explaining those changes that have taken place along the shores of the Adriatic. Having been directed by government to investigate the remedies that might be applied to the devastations occasioned by the floods of the Po, he ascertained that this river, since the period when it was shut in by dykes, has so greatly raised the level of its bottom, that the surface of its waters is now higher than the roofs of the houses in Ferrara. At the same time, its alluvial depositions have advanced so rapidly into the sea, that by comparing old charts with the present state, the shore is found to have gained more than six thousand fathoms since 1604, giving an average of a hundred and sixty

or a hundred and eighty, and in some places two hundred feet yearly. The Adige and the Po are at the present day higher than the whole tract of land that lies between them, and it is only by opening new channels for them in the low grounds, which they have formerly deposited, that the disasters which they now threaten may be averted.

"The same causes have produced the same effects along the branches of the Rhine and the Meuse; and thus the richest districts of Holland have continually the frightful view of their rivers held up by embankments, at a height of from twenty to thirty feet above the level of the land."

By similar observations on the Deltas of the Nile and the Rhone, on the depositions along the shores of the Black Sea, and the Sea of Asoph, as well as in various other places, the Baron comes to the conclusion I have already mentioned,—namely, that it can scarcely be more than five thousand years since our continents received their present form. He next proceeds to examine the progress of downs—those fearful accumulations of drift sand,—the growth of peat mosses, and the extent of mountain slips, and finds, as the result of the whole enquiry, that the Mosaic account of the time when the surface of the earth last emerged, is fully confirmed.

The irrefragable evidence to the truth of the Divine record, which has thus resulted from the discoveries of geology, is a new illustration of the fact, that it is ignorance alone which throws

doubt on so sacred a subject, and that the more accurately nature is investigated, the more clearly will she be found to bear her testimony in favour of revelation.

That the waters of a universal deluge were actually employed in effecting the changes which took place at the epoch alluded to, the discoveries of geology also abundantly attest. Nothing can be more distinctly marked than the action of a sudden and violent eruption of water on the face of the existing earth. It is seen on every part of the globe in the deposits, called by geologists *diluvium*, which every where occur in the table lands and gentle acclivities, and which, by their position, are readily distinguishable from the *alluvium* deposited by rivers or lakes. In proof of this it may be sufficient to refer to the testimony of Dr. Buckland, who says, "In the whole course of my geological travels from Cornwall to Caithness, from Calais to the Carpathians, in Ireland or in Italy, I have scarcely ever gone a mile, without finding a perpetual succession of deposits of gravel, sand, or loam, in situations which cannot be referred to the action of modern torrents, rivers or lakes, or any other existing causes. And with respect to the still more striking diluvial phenomenon of drifted masses of rocks, the greater part of the northern hemisphere, from Moscow to the Missisipi is described by various geological travellers, as strewed on its hills as well as valleys, with blocks of granite, and other rocks of enormous

magnitude, which have been drifted (mostly in a direction from north to south) a distance sometimes of many hundred miles from their native beds, across mountains and valleys, lakes and seas, by force of water, which must have possessed a velocity to which nothing that occurs in the actual state of the globe affords the slighest parallel."

On a more minute survey of the circumstances to which Buckland thus cursorily alludes, we find still more striking indications of the changes occasioned by the resistless torrent of a universal flood. It is this, as appears by the evidence of various striking phenomena, which has shaped our mountains, and scooped out our valleys; which has thrown up the remarkable undulations of our less elevated hills of gravel and loam, at the bottom of our mountain ranges; which has strewed the whole face of the earth with broken fragments of rock, rounded, by detrition, into stones and boulders; which has cast a fertilizing mould over the surface of our lower grounds; and which has submerged in the debris of the antediluvian world, those organic remains that bear such unequivocal testimony to the existence of the present races of plants and animals before that great catastrophe, and of the wide spread destruction which attended its progress.

These hints—and they deserve no higher appellation—may serve to disabuse the public mind, by shewing that the study of geology, so far from tending to encourage scepticism and infidelity,

is, when pursued in a right spirit, a powerful auxiliary of revealed religion,—throwing, as it does, new light on the events which scripture records, and, by bringing them to the test of existing phenomena, confirming these events, and the chronology with which they are connected. It is true, that the inspiration of scripture is sufficiently established, as I have already noticed, by independent evidence of a more unequivocal kind, and the Christian stands in no need of such adventitious aid; but it is assuredly satisfactory to know, that the very weapons which have been so powerfully wielded against our faith, and which have subdued so many minds, or at least strengthened them when already enlisted in the ranks of infidelity, have been wrested out of the hands of the enemy, and are now legitimately employed in a holier cause.

CHAPTER X.

ORNITHOLOGY.

Among the numerous departments of natural history, none seems more interesting than Ornithology. True, it has been stigmatized as communicating pleasure only to puerile minds, or womanish fancies, but certainly, contributing as it does, to our pleasures, to our knowledge, to the expansion of our better sentiments—both moral and religious—it well deserves the attention and the regard that is now so commonly bestowed upon it. When men scoff at any such pursuits as idle and frivolous, we may generally assign their opposition to gross ignorance and overweening vanity. Doubtless, persons have different tastes and inclinations in the selection of their studies,—it is well, indeed, that such is the case—but nothing can be more illiberal or ungenerous, and certainly nothing more injurious to the best interests of science, than to attempt to throw contempt upon any one of her branches. All the works of nature are replete with interest; and the study of them is well calculated to raise the mind

from them to their beneficent Author. In ornithology this is peculiarly the case, and in this department of science will be found matter, the knowledge of which is of the greatest utility, not only to the physical wants of man, but to his moral well-being, at least when—as he too seldom does—he not only *sees*, but also *observes*.

In all other divisions of animated nature, man finds numerous enemies to his existence, and many impediments to his peace and comfort. Among the quadrupeds, there are those that threaten him with instant annihilation; and the ocean swarms with monsters, over whom man absurdly boasts dominion, while he is unable to contend either with their voracity or their strength. Nor is the danger less that he encounters from the insect world, the individuals of which, though small, nay, often scarcely visible to the naked eye, yet convey their venom to his blood, and even acquire "a local habitation" in his very flesh, and deprive him of life by the mutiplication of their species, and the irritation caused by their presence. Among plants, also, he frequently finds a bane for which he knows no antidote; but among the feathered tribe he ever meets with friends. In whatever situation he may be, a bird is never a foe; its presence indicates to the anxious mariner the approach of land, and to the famished traveller, when not too proud to avail himself of the hint, or too lazy to observe the practical lesson it affords, a bird will point out the food of which he may fearlessly partake. The

flesh of none is poisonous, and though perhaps often unpalatable to the epicure, it will yet afford a meal to the starving wanderer; their plumage assists to keep him warm; it enriches him, when he exerts himself to collect it, and it adorns him when he requires the external symbols of wealth and of power.

To whatever division of ornithology we direct our view, we are impressed with feelings of the deepest reverence for the Creator; whether we regard the egg and its contents, its colour, the chick's egress from the shell, the formation of its feathers, its aerial wanderings, the construction of its nest, its anxious and parental solicitude:—all we see is beautiful and grand, filling the coldest minds with astonishment and admiration.

Eggs are composed of two principal parts, termed, from their colour, the yolk or *vitellus*, and the white or *albumen*. The latter does not exist in the *ovarium* or egg-bag; there, as we may see in almost every fowl that comes to table, is also a numerous collection of yolks of various sizes. When these are fully developed, they drop, one by one, through a passage termed the *oviduct* into the *uterus*, in which the egg is perfectly formed, having collected its *albumen* or white, and its calcareous shell, and from which it is ultimately expelled. The very expeditious growth or production of the white of the shell is indeed an extraordinary exertion of nature—a very few hours only being sufficient to produce them. The

texture of the shell is admirably calculated for preserving the contained parts, and for retaining the heat that is conveyed to them by incubation. Immediately under the shell is the common membrane which lines the whole cavity of the egg, except at its broad end, where there is a small space filled with air. Within this membrane, the white, which is said to be of two kinds, is contained; and near its centre, in an exquisitely fine membrane, is the yolk, which is spherical, while the white is of the same form as the shell. At each extremity of the yolk, corresponding with the two ends of the egg, is the *chalaza*, a white firm body consisting of three bead-like globules, and it is at these points that the several membranes are connected, by which means, in whatever position the egg may be placed, its various parts are retained in their proper place. Near the middle of the yolk, is a small, flat circular body, named the *cicatricula*, in which the rudiments of the future chick are contained; and from these, in consequence of incubation, or of a certain degree of continued heat of any kind, the bird is ultimately hatched. In this process, the germinal membrane, as it is called, or rudimental parts of the chick, is observed to become separated into three layers, from the external of which are formed subsequently the osseous and muscular systems, and the brain, spinal cord and nerves; while, from the middle and internal layers, are formed respectively the heart and blood-vessels, and the intestinal canal and its append-

ages. The yolk and white of the egg gradually become thinner, supplying the growing chick with nourishment, which, increasing in magnitude, at length bursts its cell and comes forth, still retaining in its intestines a portion of the yolk to serve for its support, until its powers are sufficiently vigorous to enable it to digest extraneous food.

It is a remarkable fact, that those birds, the nests of which are most uncovered, and the eggs of which are most exposed to the sight of their enemies, lay them of a colour as little different as possible from surrounding objects, so as to deceive the eyes of destructive animals; whilst, on the contrary, those birds, the eggs of which are of a deep and vivid colour, and consequently very liable to strike the eye, either hide the nests in hollow trees, or elsewhere, or do not quit their eggs except at night, or commence their incubation immediately after laying. It must, moreover, be remarked, that in those species, the nests of which are exposed, if the females alone sit on the eggs, without being relieved by the male, these females have generally a different colour from that of the male, and more in unison with neighbouring objects.

All providing nature, says Monsieur Gloger,—a distinguished German naturalist, and the first observer of this remarkable arrangement,—has thus consulted the preservation of the species, the nests of which are altogether exposed, by giving to their eggs a colour incapable of betray-

ing their presence to a distance, whilst she has been able, without inconvenience, to give the most brilliant colours in those circumstances where they are hidden from the sight.

Pure white, the most treacherous of colours, we find to be the colour of the eggs of birds which build in holes, as the woodpeckers, the king-fishers, the swifts, the dock and water swallows, and others; also of those birds, as the titmice and wrens, which construct their nests with openings so small, that their enemies cannot see into them. Moreover, we find eggs white in birds which do not quit their nests, except at night, as the owls; or for a very short time during the day, as the falcons. Finally, this colour is found in those which lay only one or two eggs, and which immediately begin to sit, as the pigeons, &c.

The clear green or blue colour, is proper to the eggs of many species which build in holes, as the starlings, the fly-catchers, &c.; it is also common to the eggs of birds, the nests of which are constructed of green moss, or situated in the midst of grass, but always well hidden. Green eggs, too, are found, with many powerful birds, able to defend them, as the herons.

A faint green colour, approaching to a yellowish tint, is observed in the eggs of birds, as the partridges and pheasants, which lay in the grass, without preparing a regular nest. The same colour is remarked in those which cover their

nests when they leave them, as the swans and the ducks.*

The structure of the feathers of birds is also highly interesting, and well worthy of consideration. If we examine one that has just begun to protrude from the sheath, we find the upper, or protruded portion, perfectly formed and developed; whilst, as it passes downwards, it assumes an appearance becoming more and more slimy, until the bottom of the sheath is filled with nothing but a mucilaginous substance. "Look," says the amiable Drummond, "at a single feather of the peacock; consider its shining metallic barbs, its superlatively beautiful eye, and all the wonders it exhibits of irridescent, rich, and changeable hues, according to the angle in which it lies to the light; that its form, its solidity, its flexibility, its strength, its lightness, and all its wonders—for, in the eye of intelligence, every part of it is a wonder,—had their origin in a little mucilage; and then consider whether in looking on such an object, we should be content with thinking no more about it, than simply that it is a peacock's feather." Yet this is too much the practice; above us, and below, on the right, and on the left, in every element, in every situation, the works of an Almighty Power are present, and all abounding in instruction of the highest kind, and yet how slight is the impression which they make upon us, in comparison with that which they are so well calculated to inspire!

* Edinburgh Journal of Natural and Geographical Science.

All the parts of animals are suited to their mode of life; and first, let us examine the feet and claws of birds. Observe how well calculated for securing and tearing their victims, are the strong, and large, and crooked talons of birds of prey; but they are not all alike, for even among the various eagles, intimately connected as they are with each other, much difference of conformation exists, according to the necessity of the case. In the osprey, the principal food of which is fish, we find the foot unlike that of other eagles, for its outer toe turns easily backwards, and what is remarkable, the claw belonging to it is larger than that of the inner toe. Like other eagles, the osprey has four toes, but nature, who never acts without a purport and intent, has thus given it the power to turn back at pleasure, one of its toes—in which position it would seem to have two back and two front toes—in order that it may the more readily grasp and secure its slippery prey.

The foot of the cuckoo exhibits the same peculiarity, for which no cause has been yet discovered. Perhaps it lays its egg upon the ground, and then conveys it in its foot to the nest where it is to be incubated. But why, it may be asked, cannot the cuckoo at once lay its egg in this nest? why does it first lay it upon the ground, and then, if indeed it does so, convey it to the place it has selected? But in reply to such queries, it has been suggested, that eggs are not laid in a moment, that some time is necessary for the

process of expulsion, and that, did the cuckoo occupy the nest for the requisite period, its original proprietor might return and expel her from her usurped possession; while, on the other hand, by laying her egg upon the ground, she can watch a favourable opportunity, and deposit it in the nest she has selected for its reception. Birds, again, that climb trees in search of food, as the woodpeckers, have a foot admirably adapted for the purpose, two claws being placed before and two behind,—a construction better adapted than any other to enable them to rest upon the trunks and large branches. While speaking of the woodpecker, I must allude to another beautiful adaptation of organization to its mode of life. Although its claws are long and much hooked, we can easily imagine that by continually clinging to a perpendicular trunk, the muscles of its legs will tire and fail. Behold now how nature has provided for this! the ten quill feathers of the tail are very stiff, and have sharp, naked points; when, therefore, the legs tire, it bends down its tail, the sharp feathers of which become opposed to the bark of the tree, and the bird is thus enabled, in a great measure, to support itself on its tail, as if upon a seat. The tail of the cormorant is also similarly composed, and is used for a like purpose when the bird sits upon rocks.*

Another instance of the beautiful adaptation of means to an end, is to be found in some of the

* Drummond's Letters.

waders, especially the herons and storks which live in the midst of marshes and muddy waters, where they find the food on which they live. Every body may have observed how long they will stand motionless and in an erect posture; and many have doubtless wondered at the length of time they can do so. This singular power, so necessary to animals obliged to obtain their prey, more by chance than industry, they owe to a peculiar conformation of the articulation of the leg and thigh. The articulating surface of the thigh bone contains, in its centre, a depression, into which is received a projection of the tibia. To enable the animal to bend its leg, that projection must be disengaged from the depression into which it is lodged, and this is resisted by several ligaments which keep the leg extended, in standing and flying, without the assistance of the muscles. But it is only birds of this description which are thus provided; and all others are obliged to employ muscular action when standing, except during sleep. In no instance has the Almighty provided more organs than are absolutely necessary to the well-being of the animal He has created.

The legs and feet of aquatic birds are wonderfully formed for accelerating their motion in that element which is their greatest security. The bone of the leg is sharp, and vastly compressed sidewise; and the toes, when the foot is brought forward, close in behind each other, in such a manner as to expose a very small surface in

front, so that in the action of swimming, very little velocity is lost in bringing the leg forward. All these birds are web-footed; but mark how different is the web in different species, and how each has its foot adapted to its mode of life. The gulls and terns, which seek their food upon the surface of the water, and cannot dive, have the back toe very small, and unconnected with the others; while in the cormorant, which seeks its prey beneath the water, we find the back toe very long, and connected with the other three; thus the whole four toes are connected together, —a circumstance which tends to give great velocity to the bird when diving in pursuit of prey. There are also some which swim and dive well, but the toes of which are long and slender, and not furnished with webs or fins, as the water hen and rail; but these, again, live as much on land as water.*

Most birds, when sleeping, roost on branches, which they grasp firmly with their claws. Here, too, we find a beautiful provision of nature, effecting the constriction, by which they cling to their support, by the manner in which the tendons of the flexing muscles of the feet descend along the legs. These tendons press behind the articulation of the heel, while a muscle which arises from the body, joins them as it passes in front of the knee, so that the bird has but to give way to its weight, and the joints becoming salient on the side along which the tendons run, stretch

* Drummond's Letters.

and pull them in such a manner as to act upon the feet, and so draw in the claws as to clasp tightly the branch on which the bird is perched.

The claws also afford a provision for ensuring cleanliness. Most birds are infested with a species of louse, which, without the sharp and scraping claws, it were impossible they could dislodge. The middle claw of some species, as the night-jar and herons, are even furnished with a comb-like appendage—it being serrated or notched along its inner edge—and as this pectinated or comb-like edge is frequently found with small portions of down adhering to its teeth, it is natural to suppose, that it is intended as a comb to rid the plumage of the head of vermin, which is the principal, and almost the only part, so infested in all birds. Mr Ainsworth, in the second number of the Journal of the Royal Institution, has related several examples of this interesting fact; and a circumstance in evidence of its truth presented itself last year to my own observation. Attached to my stables is a large paved yard, in which I attempted to keep and to rear poultry; but although the fowls when first placed there were very healthy and lively, they soon became weakly and sick. Corn would not fatten them, and, indeed, they soon scarcely heeded to run to the hand from which it was thrown. It was long before I could discover the cause of all this, but at last I caught a bird to examine it, and found it literally covered with vermin. The paved yard had blunted and rubbed down the edges of the

claws, and rendered them incapable of removing these parasitical nuisances from their feathers. I sent the birds to the country, where they soon recovered their wonted health.

Birds are in every respect admirably adapted, by their structure, to the functions they are to perform; as is beautifully seen in the organization whence they acquire the power of flying. To enable an animal to support itself, and to make progress in the air, it is necessary, in the first place, that it should be of a specific gravity, not much exceeding that of the atmosphere.—Nature has rendered birds very light,—a peculiarity which they owe partly to their very capacious lungs, which are capable of great dilatation from the remarkable mobility of the walls of the chest, and partly to the extension of the lungs into the abdomen, by means of membranous sacs, and into the skeleton, by means of canals, so that the whole body distended with air, which is rarified by a considerable degree of heat—(being about ten degrees above that of other warm-blooded animals), and clothed in feathers almost as light as air itself—requires but a moderate degree of force to support itself in the atmosphere. Expanded wings, moved by very powerful muscles, enable them to strike the air with a power, and to repeat the stroke with a rapidity, of which no other animal is capable; and thus sustaining their light bodies, to cleave the skies with wonderful rapidity. Humboldt saw the enormous vulture of the Andes, the majestic condor, dart suddenly from the bot-

tom of the deepest vallies to a considerable height above the summit of Chimbaraco, where the barometer must have been lower than ten inches; and he frequently observed it soaring at an elevation six times higher than that of the clouds of our atmosphere.

The bones of birds, in so far as their air cells are concerned, form two distinct systems,—the one being filled with air directly from the lungs, the other immediately from the mouth and nose. To the latter, the bones of the head, to the former, those of the trunk, and of the neck and extremities belong. The openings admitting air into the bones, as their connection with the lungs or air-tubes renders necessary, are situated in concealed parts, and in the extremities of the bones; and this circumstance, coupled with their smallness, makes their discovery so difficult, that in many cases the minutest examination of the surface of the bone is necessary to discover their existence. In long bones, the openings of the air cells are generally situated close to either extremity. In bones which exist in pairs, there is commonly only one; or where several exist, they are so close together, as to be nearly united. Sometimes the opening is oblique, so that a short oblique canal is formed; at others there is an oblique groove, with a sieve-like base for the entrance of the air. The edges of the openings are even smooth and rounded, which gives them a peculiarly regular appearance. Their shape is either circular, oval or elliptical. Their breadth

bears some kind of proportion to the size of the bone, or at least to the extent of the internal cells, so that large birds, and large bones, have much larger openings than small ones. With respect to the internal air cells, great differences exist. It is known that the air bones in young birds are filled with marrow, which becomes gradually absorbed, to make room for the admission of air. This gradual expansion of the air cells and absorption of the marrow, can no where be observed so well as in young tame geese, when killed at different periods of the autumn and winter. The limits of the air cells may be clearly seen from without, by the transparency of the bones. From week to week the air cells increase in size, till, towards the end of the season, the bones become entirely transparent. In all these bones, the marrow disappears first from the vicinity of the opening which admits the air, while it continues longest at the points farthest removed from it. Towards the close of the summer and beginning of autumn, although in external appearance the young goose resembles the parent, no traces of air cells can be discovered in the bones, the interior of them being then filled with marrow, which does not begin to disappear until the fifth or sixth month. Whether birds possess the power of voluntarily letting out the air, so as to render themselves specifically lighter, has not yet been determined.*

Let us now enquire how birds, endowed with

* Lancet, 1828.

an organization so favourable to flying, perform that action. A bird, says Richerand, begins by ascending into the air, either by rising at once from the ground, or by allowing himself to fall from a height. If, on the ground, and if his wings are too large to be freely spread, he has difficulty in rising. In that case he goes to an elevated spot, and throws himself from it, that he may have sufficient room to spread his wings, and strike, in the air, the first stroke that is to raise him. The wings expand horizontally, the single bone which forms their upper and principal part, standing off from the body; they then ascend rapidly, and, as the air resists the sudden effort which tends to depress it, the body of the bird is elevated by a kind of elastic reaction, corresponding to the leap of man, and to the swimming of fishes. The impulse being given, the bird closes his wings and contracts his dimensions as much as possible, that the impulse may be almost entirely employed in raising his body, and may not be counteracted by the resistance of the air. This resistance of the air, but particularly the weight of the bird, would soon overcome the velocity which has been obtained, and he would drop, if, by again striking the air, he did not again rise. If the bird strike a second time with his wings, before the impulse communicated by the first stroke be over, he rises rapidly, but on the contrary, descends, if this motion be delayed. Again, if he allow himself to fall only to the height whence he began to rise, he may,

by a continuation of equal vibrations, keep at the same height. A bird sometimes ceases altogether to move his wings, closes them against his sides, and falls with a precipitate motion, like any other weighty body. Observe a hawk drop suddenly on a poultry yard; if, on the point of reaching the ground, he perceive danger, he immediately spreads his wings, and thus saves himself from falling; he then rises anew, and takes to flight.

The oblique motion differs from the vertical motion which has just been described, in this, that the bird rises by a series of curves which are more or less extended, as the motion is more horizontal or vertical. In consequence of the peculiar strength of their wings, birds of prey have a very powerful horizontal motion, so that in soaring, the curves which they describe are so slight, that the motion seems quite horizontal.

Those visionaries who have conceived it possible for man to support himself in the air, by rendering his body specifically lighter, have not considered, that it is impossible to give to the muscles which move the arms a sufficient degree of strength to enable them to move the machines which are adapted to them; and hence, all who have thus Icarus-like, attempted to fly, have suffered for their rashness.*

The throat-bone of a bird, which furnishes an attachment for the principal muscles moving the wings, presents an area much greater than that

* Richerand's Physiology.

that of any other bone of the body; while the muscles attached to it weigh more than all the other muscles of the body put together! Let us compare with these the sternum and pectoral muscles of man, in relation to the rest of his bones and muscles, and learn to be contented with the functions to which our structure is adapted.

Turning from this to another function, I have to remark, that many birds have a mode of triturating their food, distinct from those employed by most other animals. In the latter, this is effected by the teeth, which birds do not possess; and, therefore, it was necessary that other means should be provided for them, of tearing and destroying the texture of their aliment, in order to expose all parts of it to the action of the fluids poured into the stomach, and thus to render it fit to nourish and repair the body. The organ for effecting this purpose is the gizzard,—an immensely strong hollow muscle, lined with a substance so thick and callous, as not to be hurt even by grinding down glass, and always found to contain small stones, or the hardest materials the bird can procure. By the help of these stones, and by means of the hard internal coat of the gizzard, and its muscular force, the food is effectually ground down, and fitted for the offices assigned to it. Spallanzani, and others, have denied that such is the use of these stones, and have affirmed that they were picked up by mere accident, the animals mistaking them for seeds. This supposition, however, is easily disproved by

the well known fact, that birds confined in cages, and having no sand or small stones supplied to them, soon die, and that when examined, their intestinal canal is found with indigested seeds in it; which, otherwise, is not the case. In order to ascertain the power of the gizzard, Reaumeur gave to a turkey, small tubes of glass five lines in length and four in diameter; in twenty-four hours these were found to be broken. He substituted tubes of tinned iron for the glass, some of which were indented by the gizzard, and others flattened. Similar tubes placed in a vice required a force of four hundred and thirty-six pounds and a half to produce the same effects!

All birds, however, have not a gizzard. Some, as birds of prey in general, possess a purely membranous stomach; but such are furnished with strong, sharp and crooked bills, for the purpose of tearing their food into small pieces, so as to supersede the necessity of any further trituration.

But it is far from my intention to enter fully upon the anatomy and physiology of the feathered race of beings. In another part of this work I have alluded to some of the beautiful adaptations of their structure to the circumstances and destinies they are intended to fulfil; and the facts detailed in this chapter seem sufficient to illustrate and confirm the proofs there given of the wisdom displayed by the great Creator in this department of the animal world. Nothing can be more worthy of remark than the exhaustless, and, if the expression be allowable, the ad-

mirably *ingenious* contrivances by which every difficulty is obviated, and nature is moulded to the will of its Almighty Author. How many obstacles were to be overcome before a heavy body like that of the eagle, to an account of whose noble faculties I shall devote the next chapter, could be rendered buoyant in the air, and made capable of tracking its adventurous course from Alp to Alp, so high above the earth as to be lost to human gaze! How many conditions were necessary to give safety and enjoyment to the very smallest of the winged tribes, even after the first obstacles were overcome! Yet how wonderfully simple and efficacious the means by which the whole has been accomplished! That man is indeed to be pitied, who can turn even a transient glance on such a subject, without being lost in astonishment and adoration.

CHAPTER XI.

ORNITHOLOGY CONTINUED.—THE EAGLE.

EAGLES are now of great rarity in Britain, the influence of man having almost expelled them from their pristine haunts. It is only in the remote solitudes of the Highlands, and in the isles of the north-west coasts, that they occur in something like the proportion which, in the wild state of the country, they bore to its other inhabitants. Even there the ingenuity of man has wrought sad havoc among them; but in the inaccessible parts of the precipitous mountains, and on the awful heights of the maritime cliffs, the eagles of the north still rear their young, and bid defiance to all means of destruction.

Only two species of eagle have been ascertained to reside in this country, although till of late ornithologists were in the habit of describing four,—a circumstance which arose from the differences in colour which these birds exhibit at different periods of life. These two species are the golden eagle and white-tailed eagle.

The golden eagle (*falco fulvus*) called also *falco chrysaëtos*, is a beautiful and majestic bird.

In the adult state, the feathers of the head and neck are of a brownish red colour, the other parts of the body being dark brown. The length of the male is about three feet; that of the female about three and a half.

At the age of from one to three years, this bird is of a pale brown colour, with the under tail feathers whitish; but as the bird advances in age, the colours become darker, the white of the tail occupies less space, and indications of bands make their appearance. In this state the golden eagle has been described as a distinct species, under the name of the *ring-tail.*

The golden eagle is of rarer occurrence in Scotland than the white-tailed eagle. It feeds chiefly upon live prey, destroying grouse, hares, lambs, and other animals; but it does not disdain to feast upon carcases of all kinds. It builds in inaccessible places of maritime and inland cliffs, making an enormous nest of sticks, heath, grass, wool and feathers, which it puts together in a very inartificial manner. Mr. M'Gillivray speaks from personal observation when he says, that it places its nest on a shelf of some vast cliff overhanging the sea, or in a cleft of a rock in the inland solitudes. The diameter of the nest is about five feet, and it consists of sticks, tangles, (stems of the *fucus digitatus*), heath, and other materials of a like nature, arranged in the same slovenly manner as the straws in a hen's nest, together with grass, wool and feathers.

The central part of the nest is slightly hollow, and about two feet in diameter. In this there are deposited two eggs, about the size of those of the goose, but shorter, and of a yellowish white colour. They do not appear to be left exposed at any time, for it seems that the male sits when the female is absent.

The white-headed or cinereous eagle, (*falco albicilla*) is a less active bird than the golden eagle, although it is nearly equal to it in size and strength. In the adult state, the cinereous eagle has its plumage of a very pale brown colour, and a tail purely white. Its length varies from two and a half to three feet, but the extent of its wings is sometimes eight feet.

At the age of from one to three years, this bird is of a dark brown colour, with the appearance of white spots, occasioned by the lower part of each feather being of that colour. The under parts are of a deeper brown, spotted with white. In this state it has been described by authors as the sea eagle, (*falco ossifragus.*) This species is much more common than the other. It feeds chiefly upon carrion of all kinds, especially fish. It also destroys living animals, as game, lambs and fish. It does not, of course, dive after the fish, but is said to pounce upon them when they come to the surface. In the seas of the northern parts of Scotland eagles might easily live this way, since many fish, as the herring, the dog-fish and cod, frequently swim in vast numbers along the surface of the

water. In the shallow rivulets, also, trout and salmon swarm at certain seasons, and might easily be captured. Some years ago, a large salmon was found dead, and an immense eagle drowned beside it, with the claws of the one stuck into the back of the other, upon the banks of Moffat water. A few days before, a party of young men had started on a Sunday night to spear salmon by the light of a blazing torch; Moffat water, from its general shallowness, and the nakedness and level character of its banks, offering unwonted facilities for this sport. The parties had scarcely begun to search the pools, when they were astonished with some strange noise that came "splash, splash" upon them; and soon a huge pair of wings appeared, magnified by the uncertain light, and accompanied with other startling and unearthly noises. The phenomenon floated past, almost among their feet; and the young men terrified, and impressed with the idea that an apparition had appeared to warn them of the danger of misspending the Sabbath day, left their sport and returned home. The circumstance was kept a profound secret, until the discovery of the cause of the phenomenon relieved the youths from the fears which it had excited.

Eagles are very destructive to lambs, but they seldom attempt to carry them off, excepting from an eminence; for from a flat surface an eagle rises with great difficulty, and not until after repeated flappings of its wings, although in the air it ex-

hibits great facility of motion. Mr. M'Gillivray, upon whose notes in the columns of the Edinburgh Literary Gazette, I have already largely drawn, says,—"Nothing can be more beautiful than the majestic sweep of an eagle while passing along the sides of the mountains in search of prey;" and both Audubon and Wilson, in their American Ornithologies, have celebrated the flight of many species of this beautiful family. Speaking of the bald eagle, Wilson says, "its flight is both noble and interesting. Sometimes the human eye can just discover him, like a minute speck, moving in slow curvatures along the face of the heavens, as if reconnoitring the earth at that immense distance. Sometimes he glides along in a direct horizontal line, at a vast height, with expanded and unmoving wings, till he gradually disappears in the distant blue ether. Seen gliding in easy circles over the high shores and mountainous cliffs that tower above the Hudson and Susquehanna, he attracts the eye of the intelligent voyager, and adds great interest to the scenery. At the great cataract of Niagara, there rises from the gulf into which the Fall of the Horse-Shoe descends, a stupendous column of smoke or spray, reaching to the heavens, and moving off in large black clouds, according to the direction of the wind, forming a very striking and majestic appearance. The eagles are here seen sailing about, sometimes losing themselves in this thick column, and again reappearing in

another place, with such ease and elegance of motion, as renders the whole truly sublime,

> "High o'er the watery uproar, silent seen,
> Sailing sedate in majesty serene,
> Now 'midst the pillar'd spray sublimely lost,
> And now, emerging, down the rapids tost,
> Glides the bald eagle, gazing, calm and slow,
> O'er all the horrors of the scene below;
> Intent alone to sate himself with blood,
> From the torn victims of the raging flood."

Where eagles are so numerous as to commit serious ravages among the young lambs, the following methods have been used for destroying them:—When the nest happens to be in a place, situated in the direction of a perpendicular from the edge of the cliff above, a bundle of dry heath or grass, inclosing a burning peat, is let down into it. In other cases, a person is lowered by means of a rope, which is held above by four or five men, and contrives to destroy the eggs or young, taking a large stick with him, to beat off or intimidate the old eagles. The latter, however, generally keep at a respectful distance; for, powerful as they are, they possess little of the courage which has in all ages been attributed to them; being, in this respect, much inferior to the domestic cock, the raven, the sea swallow and numerous other birds. Sometimes eagles have their nest in places accessible without a rope; and instances have been known of persons frequenting these nests for the purpose of carrying off the prey which the eagles convey to their young.

A very common method by which eagles are destroyed is the following :—In a place not far from a nest, or a rock on which eagles repose at night, or on the face of a hill which they are frequently observed to scour in search of prey, a pit is dug to the depth of a few feet, of sufficient size to admit a man with ease. The pit is then covered over with sticks and turf, the latter not cut from the vicinity, since eagles, like other cowards, are extremely wary and suspicious. A small hole is left at one end of this pit, through which projects the muzzle of a gun, while at the other is left an opening large enough to admit a featherless biped, who, on getting in, pulls after him a bundle of heath to close it. A carcass of a sheep or dog, or fish or fowl, having been previously left without, at the distance of twelve or twenty yards, the lier-in-wait watches patiently for the descent of the eagle, and, the moment he has fairly settled on the bait, fires. In this manner multitudes of eagles are every year destroyed in some parts of Scotland. The head, claws and quills, are kept by the shepherds to be presented to the factor at Martinmas or Whitsunday, for the premium of from half-a-crown to five shillings, which is usually awarded on such occasions.

Not long since, the following regular engagement took place between a shepherd and an eagle upon the hills near Moffat :—On the farm of Gameshope, the eagle of which I speak had frequently lifted lambs within twenty yards of

the shepherd, and when the dogs were encouraged to interfere, beat them off, and even struck them to the ground with his powerful wings, retiring a little way, and finishing his repast with the greatest coolness. Success and impunity made him bold as a lion. During the spring, his haunts had been the heights of Fruid and Gameshope, and more especially a spot called Loch-hill, which he began to regard as his own territory, suffering no rival to approach his throne. Repeatedly he disputed the shepherd's right to visit the hill, while looking after the safety of his master's flocks, screaming and flying round him, and sometimes stooping within a yard of his head,—"willing to wound, and yet afraid to strike." This state of things could not be allowed to continue; and accordingly, the shepherd having collected a quantity of stones, stowed them in his plaid, and approached a heathy knoll, white with the skins and bones of slaughtered lambs. The eagle met him; by turns rising and stooping, but never flying away. Meanwhile the shepherd assailed him with his missiles, until one stone, "more lucky than the rest," struck, stunned and brought to the ground the feathered freebooter: the dogs now rushed to the mêlée, and the noble bird was soon overpowered and destroyed. Each wing was four feet long, and the legs nearly as thick as a man's arm.

But it is not man alone that the eagle has to fear; for the skua gull (*lestris cataractes*) is also

its enemy. To this bird in Shetland, where it is called *buncie*, is almost entirely trusted by the natives the protection of their lambs from the ravages of the eagle, during the summer months; and there, in return for the care they afford, they are always allowed to wander unrestrained over the island, being regarded with great veneration and kindness. The skua gull possesses an inveterate dislike to the eagle; for, no sooner does he emerge from his rocky habitation among the cliffs, than the gulls descend upon him from the tops of the mountains, in bodies of three or four, and never fail to force the eagle to a precipitate retreat.

"I was particularly amused one evening," says Mr. Drosier, in Louden's Magazine of Natural History, for July 1830, "when standing at the foot of the loftiest hill (called by the natives *Snuge*), with the following circumstances:—An eagle was returning to his eyrie, situated on the face of the western crags, in appearance perfectly unconscious of approaching so near to his inveterate foe, as, in general, the eagle returns to the rocks from the sea, without ever crossing the smallest portion of the island. This time, however, he was making a short cut to it, by crossing an angle of the land. Not a bird was discernible: a solitary skua might, indeed, be occasionally seen, wheeling his circling flight around the summit of the mountain, which was already assuming its misty mantle. As I was intently observing the majestic flight of the eagle,

on a sudden he altered his direction, and descended hurriedly, as if in the act of pouncing; in a moment five or six of the skua passed over my head with an astonishing rapidity; their wings partly closed and perfectly steady, without the slightest waver or irregularity. They appeared, when cleaving the air, like small fragments of broken rock, torn and tossed by a hurricane from the summit of a towering cliff, until, losing the power that supported them, they fell prone to the sea beneath. The gulls soon came up with him, as their descent was very rapid, and a desperate engagement ensued. The short bark of the eagle was clearly discernible above the scarcely distinguishable cry of the skua, who never ventured to attack his enemy in front; but, taking a short circle around him, until his head and tail were in a direct line, the gull made a desperate sweep or stoop, and, striking the eagle on the back, he darted up again almost perpendicular; when, falling into the rear, he resumed his cowardly attack. Three or four of these birds, thus passing in quick succession, invariably succeed in harrassing the eagle most unmercifully. If, however, he turns his head previously to the bird's striking, the gull quickly ascends without touching him. This engagement continued some time, the eagle wheeling and turning as quickly as his ponderous wings would allow, until I lost the combatants in the rocks. As soon as this is the case, the gulls leave, and quietly return to the mountain."

Dumfries and Galloway were once celebrated for the number of eagles within their bounds; but, at the time I write, I doubt whether a pair is to be found wild and unconfined in the former county, or more than a dozen in the wide district of Galloway—between the Nith and the Mull. The only individuals with which I am acquainted inhabit the lofty hill of Cairnsmuir, where they are protected with the most religious care by the proprietor. It seems to be a law in the economy of nature, that, as civilization and cultivation extend over the soil, the most savage and least gregarious of its inhabitants depart from it.—Doubtless, when the Almighty decreed that by the sweat of man's brow alone should the earth bring forth her increase, He also decreed that with the progress of industry and labour, the earth should be delivered from those pests, both vegetable and animal, which naturally infest it; and the geographical distribution of the eagle, and other predatory animals, as well in the new, as in the old world, well illustrates this position.

CHAPTER XII.

ICHTHYOLOGY.

The emphatic language of Job has declared, that the fishes of the sea shall make known the glory and the greatness of God; and in few departments of His works does the Providence of the Creator shine forth with more brilliant lustre. He who has peopled the earth and the air with their myriads, has also filled the mighty caverns of the deep with untold numbers of animated beings—all fully supplied with an organization admirably adapted to the circumstances in which they are so wonderfully placed. It was not sufficient for Him, that the earth should abound with waters, the various qualities of which might be serviceable to mankind; it was not sufficient for Him that the vast expanse of ocean should obey certain fixed and immutable laws, and thereby clearly shew that truly it is a God who rules the sea; He willed that its immeasurable spaces should be inhabited, and in His goodness He decreed, that while the beings which sport there should serve as food for man, their structure should tell of the hand that made them.

The department of natural history on which I am now entering is well calculated to fill the mind with awe and astonishment, both from its vastness, and the beautiful beings of which it treats. But the subject itself is inexhaustible; and, having already alluded incidentally to the structure and organs of fishes, in common with those of other tribes of animals, as adapted severally to their respective functions, I propose at present merely to present a more particular illustration of the general economy of this class of animals.

By the generic term Fish, is understood a class of animals living in water, swimming by fins, and having the water directly applied to the gills, through which organs the whole mass of blood circulates. By this definition, it will appear that many animated beings, inhabitants of the waters, are excluded from the class of fishes; but of these it is not my intention at present to speak.

The bodies of fishes are, for the most part, narrow, that is to say, they are longer than they are wide, as in the herring and salmon. Sometimes they are flat, as in the sole and skate, and at other times again, almost cylindrical, as in the eel and lamprey.

In most fishes the mouth projects from the fore part of the head, but in some, as the sturgeon, it is on the lower part of this organ. In some species, as in the carps, the lips are moveable and furnished with a peculiar bone, and in the voracious spe-

cies, as the trout, we find the jaws, palate and tongue supplied with teeth. The upper jaw of the sword fish protrudes considerably beyond the lower, and both jaws of the garpike are considerably elongated into sharp points; while—such is the great difference of structure—the jaws of others are furnished with long vermiform processes, called cirrhi, and serving them in the capacity of antennæ or feelers. The teeth of fishes are adapted, as I have elsewhere observed, rather for tearing and lacerating, than for chewing their food, and their tongue is of very various character, corresponding to the habits of each; but they are all alike destitute, for an obvious reason, of salivary glands.

The intestines of fishes are generally very short, especially those of voracious fishes, which, feeding for the most part carnivorously, very rapidly effect the necessary changes in their aliment. In many fishes, as in the carp for example, the stomach is not separated from the intestines. The salmon, perch and others, in which, from the nature of their food, it is necessary that it should remain longer in the body to undergo the requisite changes, have their intestines furnished with many vermiform appendages, which appear to secrete a liquid analogous to the pancreatic fluid of the higher classes of animals, and probably of essential use in their digestion.

In all fishes, the liver is large and the secretion of bile very copious. This fluid finds its way by regular ducts into the intestines, where, meeting

with the liquid just alluded to, it assists in the process of digestion and assimilation. Fishes generally bolt their food—their gullet being of enormous size—and this is accordingly often found in their stomach retaining its natural form, but when touched, quickly dissolving into a jelly. From this circumstance it would appear, that digestion is in them the result of some menstruum capable of dissolving the food, without mastication, as in the mammalia, or trituration, as in birds. The lacteal or absorbing vessels of the intestinal canal of fishes are very numerous; and these, having collected all the nutritious juices from the intestines, unite together into several large ducts, which run upwards along the side and back part of the œsophagus, and pour their contents, to be mingled with the blood, into the subclavian vein.

The heart of fishes, for the most part, is triangular, and generally very small in proportion to the size of the animal. It consists of only one auricle and ventricle; and from the latter cavity a large vessel is sent which is entirely distributed upon the gills. These latter organs perform the same office as the lungs in the higher animals—affording a means by which the blood is enabled, by coming into contiguity with the air, either on land or in the water, to abstract a portion from it and thereby become fit to perform the multifarious purposes for which it is destined. They are placed on each side, immediately below the neck—if, indeed, an ani-

mal, the head of which is so intimately connected with the trunk, can be said to possess such an organ. In scaly fishes they are generally covered by two or three osseous plates, called an operculum, and in others, as in eels, by a simple membrane. In some fishes the gills are, in this manner, entirely concealed, in others they are but partially covered, and again in some they are freely exposed. The gills generally contain, on each side, four cartilaginous or osseous circles—attached to small bones united to the palate—to each of which is fixed a double row of finger-like processes, or rather penniform laminæ, of a red colour, and consisting of terminations of the large vessels already mentioned.—Here the blood loses its grosser particles, while the oxygen, which has been spent in the course of its circulation through the body, is here supplied from the water, in which the gills freely play. The water passes in at the animal's mouth, which contains several large openings communicating with the gills, over which it spreads, and, when the animal shuts its mouth, escapes at the opercula or gill covers. The water acts not only chemically, but also mechanically upon the gills by separating their laminæ to facilitate its access. Without this wise provision, fishes would die as speedily in water as they do in air, as may easily be seen by compressing their gills, and thus preventing the necessary access of the oxygenating medium; while on the other hand, the life of fishes may be prolonged in air by artificially keeping the

laminæ in the state of separation which the water produces. But it is not all aquatic animals that are thus furnished with an apparatus by which the air contained in the water is subservient to life: cetaceous animals, as those of the whale kind, respire, like men and quadrupeds, by means of lungs; and, of course, they are obliged at certain intervals to come to the surface, in order to throw out their former air, and to take in a fresh supply. Some fishes, also, as the lamprey and myxine, possess, instead of gills, several small vesicles on each side of their gullet over which the water, entering from the mouth, is again expelled, generally by small apertures on each side of the body.

With respect to the senses of fishes, there can be no doubt that they enjoy the sense of smell, and that they are acutely sensible of odorous bodies; so much so, indeed, that the very perfection of this function is often fatal to them; for some kinds are so strongly allured by aromas, that by smearing the hand over with them, and immersing it in water, they will often flock towards the fingers and may be easily taken. In all fishes, external openings or nostrils are very apparent. They generally constitute, it is true, only blind sacs; but their inner surface is of considerable extent, and upon their lining membrane, a pair of large nerves, analogous in their function to the olfactory nerves of man, are distributed.

Fishes have in general no eyelids, but in place

of them nature has given to some species a palmated process connected with the iris, which the animal has the power of raising or depressing according to circumstances. The humours of the eye are proportionally in greater quantities, or much larger than those of animals living in air. Thus the eye of the cod is very nearly of the same weight, and its axis of the same length as the eye of the ox. The cornea, however, is not so convex as that of land animals, because little or no refraction of light takes place in this membrane in fishes; but then the crystalline lens, on the contrary, is almost spherical, compensating thus for the comparative flatness of the cornea. In all animals the eye is a perfect optical instrument, and admirably adapted to the circumstances in which each species is placed. We know it to be composed of membranes and humours of different densities, so that they may transmit and refract the rays of light with the greatest regularity and exactness. In the eyes of all animated beings, we see the wisdom and beneficence of the Creator. If the animal dwell in the water, the cornea is flat, and the lens spherical; if on the surface of the earth, we find, on the contrary, the cornea more projecting, and the lens more flat; and again, if it wing its airy flight above us, its cornea is the most projecting, and its lens the flattest of all.

That fishes hear also—although the fact was for a long time doubted—is sufficiently obvious from many circumstances, and among the rest,

from their having been known to obey the call of those by whom they were accustomed to be fed. They have also a sufficiently complicated organ, though concealed in general, in the depth of their skull, for this purpose.

The taste of fishes is also very acute; and their touch not less so than that of animals in general. It is astonishing, however, what an extreme degree of heat some fishes can bear. "In the thermal springs of Bahia in Brazil, many small fishes were seen swimming in a rivulet which raises the thermometer eleven degrees and a half above the temperature of the air. Sonnerat found fishes existing in a hot spring at the Manillas at a hundred and fifty-eight degrees Farenheit; and Humboldt and Bonpland, in travelling in South America, perceived fishes thrown up alive, and apparently in health, from the bottom of a volcano, in the course of its explosions, along with water and heated vapour that raised the thermometer to two hundred and ten degrees, being but two degrees below the boiling point."*

The bodies of most fishes are covered with small brilliant plates of a horny nature, called scales; but in certain kinds these are wanting, as in the turbot, in place of which are found osseous or cartilaginous protuberances in some species, and in others a very smooth skin, without scales or rugosities, but covered with a thick gelatinous secretion. It was observed by Steno, in the skate, that this slimy matter was poured

* Jameson s Journal.

out from numerous orifices regularly placed near the surface; and Dr. Monro has recorded his discovery of a very elegant structure for the preparation of this mucus between the skin and muscles. The secretion is so viscid that it is with great difficulty pressed out. There is a species of carp—the rex cyprinorum of Linnæus—that seems to hold a middle place between the rough and smooth skinned fish; the upper part and back is covered with scales, while these are altogether wanting in the lower part and belly.

The brain of fishes is smaller in relation to their body than in other vertebral animals. It does not exceed in the barbot the seven hundredth, in the pike the one thousand three hundredth, and in the tunny even the thirty-seven thousandth part of the weight of the body; but still the nerves going from it are as large in proportion to the several organs, as in the other classes.

Fishes have a firm and compact body, heavier than the element in which they exist; and it follows, that they would have sunk and remained at the bottom, had not the Almighty provided an apparatus by which they could rise and swim about at pleasure. "Fishes are adapted," says Richerand, "by their structure, to the element in which they live; the form of their body bounded, every where, by salient angles, is well calculated to separate the columns of a fluid. A bladder filled with air, which is expelled at pleasure, renders their specific gravity less than that of

water, according to the quantity of its contents." Perhaps one mean of diminishing the specific gravity of the bodies of fishes is the quantity of fat with which they in general abound; but the principal instrument for effecting this is undoubtedly their air-bladder. This gives to their back a sufficient degree of lightness to enable it to remain upward, else this part of the body, which is the heaviest, would draw after it the rest, and the animal, lying on its back, would be incapable of performing any motions of progression, as happens when the bladder is burst or punctured. Hence, too, such fishes as naturally want an air-bladder generally remain in the mud at the bottom of the water. Constrictor muscles expel the air which it contains, and force it into the stomach or œsophagus, when the animal wishes to sink; but this expulsion becomes impracticable if the air undergoes considerable expansion from any cause, and resists the compression that is applied to it, as when fishes are contained in a vessel which is placed under the exhausted receiver of an air-pump. Hence, also, during the fry time, fishes, after remaining long on the surface of the water, exposed to the heat of the sun, become unable to sink, and are easily caught.— But not only was it necessary to supply fishes with the power of sinking to the bottom or floating on the surface of the water—the means of supporting themselves and of making progress in the water were also to be provided. Accordingly their tail, moved by powerful muscles, may be

considered as an oar of great strength, the motions of which impel the fish forwards, while the fins, like so many secondary oars, facilitate and direct its motions.

The trunk of fishes includes the chest, belly and tail. The chest—which is very short, the gills belonging to the head—is separated from the belly by a white and shining membrane called the diaphragm ; the belly is the portion of the body placed between the chest and the tail, the latter of which forms the termination of the trunk. In some species the belly is wide and thick, while in others it is narrow and slender ; the back of some is much rounder than of others, but in the greater number it forms an edge more or less acute. The sides are placed between the margins of the belly and back, and in most species we find a mark, called the lateral line, running throughout their length.

The fins are named according to the parts to which they are appended : thus we have the dorsal, the pectoral, the ventral, the anal and the caudal fins. The dorsal fin, situated on the back, is either single, as in the pike ; double, as in the perch ; or triple, as in the cod and haddock ; or it may be altogether wanting. Some species, as the salmon, possess an elongation of this fin, to which the term *adipose* has been applied.—The pectoral fins are placed on each side, near the opercula or gill covers. In some species they are wanting, and others have two on each side. In some species, as the flying fish, they are so

considerably elongated, that with their aid, the animal can sustain itself for some time in the air. The ventral fins, as their name denotes, are placed on the lower or under part of the fish. Their situation, however, is not uniform, for we find them either near the mouth, on the chest, or on the belly. Thus we have the *jugulares*, of which the haddock is an example, where the ventral fins are placed before the pectoral fins, or under the throat; the *thoracini*, as the perch, where they are placed on the breast, immediately under the pectoral fins; and the *abdominales*, as the salmon and perch, where they are placed on the belly, behind the pectoral fins. The anal fin is placed between the anus and caudal fin or tail, which is situated at the extremity of the body; and which is variously shaped, and serves to form distinctive characters by which fish are divided and arranged in classes, genera and species.

The fins themselves are formed of skin, stretched or extended on osseous or cartilaginous rays, and united to the body by means of certain peculiar bones. The pectoral or ventral fins alone, however, can be said to correspond to the upper and lower extremities of the higher classes of animals. They are acted on by several muscles admirably adapted to the necessities of the animal. Thus we find in the pelagian tribes, which traverse the ocean contending with waves and currents, large and strong fins furnished with powerful muscles; while those which delight in

quiet shores and fresh waters have but delicate fins, and inconsiderable muscles. The number of the rays is variable, and affords the principal character to distinguish species. The fins and tails furnish the chief organs of motion and progression to fish; and with their aid they traverse with the greatest rapidity thousands of miles in a season. Large fishes are known to overtake, and play around, with great ease, a ship in full sail; and it has been calculated that a salmon will glide over eighty-six thousand four hundred feet in an hour, and twenty-four feet in a second, that it will advance more than a degree of the meridian of the earth in a day, and make the tour of the world in a few weeks.

The fins not only assist the animal in advancing, but in rising and sinking, in turning, and even in leaping out of the water. To answer these purposes, the pectoral fins, like oars, serve to push the animal forward; they likewise balance the head, when it is too large for the body, and prevent it from falling prone to the bottom, as happens to large headed fishes, when their fins are cut off. The ventral fins, which lie flat in the water, in whatever situation the fish may be, serve rather to depress the body, than to assist its progression. The dorsal fin poises the body and preserves the animal's equilibrium, while at the same time it aids its forward motion. The anal fin is designed to maintain the vertical or upright position of the body. Lastly, the tail may be regarded as a rudder, or directing instrument

of motion, to which the fins are only subservient. This is easily ascertained if we put a fish into a large vessel of water. When in a state of repose, it will be seen to spread out all its fins, and to rest near the bottom on the pectoral and ventral; and, if it fold up either of its pectoral fins, it will incline to the side on which the folding takes place. When it desires to have a retrograde motion, striking with the pectoral fins in a contrary direction, effectually produces it. If it desires to turn, a blow from the tail sends it about; but if the tail strike both ways the motion is progressive. If the dorsal and ventral fins be cut off, the fish reels to the right and left, and endeavours to supply the loss by keeping the rest of its fins in constant motion. If the right pectoral fin be removed, the fish leans to that side; and if the ventral fins on the same side be cut away, it entirely loses its equilibrium. When the tail is removed the animal loses all power of motion, and abandons itself to the impulse of the water.

Fishes, however, that have the greatest number of fins have not always the swiftest motion. The haddock, with its full set of fins, is very slow and tardy, while the shark, which wants the ventral fin, is the swiftest swimmer. Again, notwithstanding their agility and swiftness, fishes often remain in a state of inactivity and supineness, until aroused by the dread of an approaching enemy, or the calls of hunger. But it is not only by their swiftness that fishes are enabled to avoid danger and destruction. Another great

means which all bountiful nature has given to fishes of escaping from their enemies, is to be found in the truly wonderful power which many, if not all possess, of changing their colour, and accommodating it to that of the element in which they are seen. This is easily observed in the minnow, stickleback and perch, when kept in a basin of water, particularly, however, in the stickleback, in which the changes of colour are more remarkable than in the minnow and perch, inasmuch as they take place more rapidly. Even in a few minutes, and under the naked eye, the colours may be seen to fade or brighten, according to the nature of the vessel in which they are placed. "May not these changes of colour in fish," asks Mr. Stark, by whom the observation seems to have been first recorded, "depend much upon the same cause as the changes which take place in the colour of the camelion, and of which no satisfactory account has yet been given? When crawling on plants, the keenest eye cannot detect its presence, as being different in colour from the exact shade of the leaves." Both exhibit a most unanswerable example of the care of God for the meanest of His creatures, and cannot be for a moment contemplated without an overpowering conviction of His all-provident wisdom and goodness.

What I have hitherto said of the functions of fishes appertains to those only which are subservient to the welfare of the individual: but no less care has been bestowed upon the perpetua-

tion of the species. In comparison with other oviparous animals, the eggs of fish are very small; they are, however, far more numerous, and while they furnish food to many of their own kind—even to the individuals from which they sprung, and to various kinds of fowl, yet still do we find the waters abundantly supplied with inhabitants. "Let the waters bring forth *abundantly*," said the Lord; and when we consider the astonishing fecundity of a single fish, we shall find how truly the Divine command has been obeyed. According to Lewenhoeck, the cod annually spawns upwards of nine millions of eggs contained in a single roe; the flounder produces above a million; and the mackarel above five hundred thousand; a herring of a moderate size will yield at least ten thousand; a carp of fourteen inches in length contained, according to Petit, two hundred and sixty-two thousand, two hundred and twenty-four; a perch deposited three hundred and eighty thousand, six hundred and forty; and a female sturgeon, seven millions and fifty-three thousand, two hundred.

Most fishes take no care of their offspring, and some even cast their spawn indiscriminately among the waters, and leave them to an uncertain chance. This, however, is not the case with all; certain species of the genus *doras*, make a regular nest, in which they lay their eggs in a flattened cluster, and cover them over most carefully. Nor does their care end here, as with most others who cover their spawn, for they re-

main by the side of the nest, till the spawn is hatched, watching it, and attacking most courageously every assailant. Hence, the negroes frequently take them by putting their hands into the water close to the nest, on agitating which the male springs furiously at them and is thus captured, falling a victim to his paternal solicitude. Aristotle tells us, also, that a fish named *phycis* makes a nest like a bird. This was long considered to be fabulous, but M. Olivi has lately found a fish, named *gou* or *gau*, (*gobius niger*) which has similar habits. The male, at the period of impregnation, digs a hole in the mud, surrounds it with weeds, forming a nest of it, near which he meets the female, and from which he does not stir, until the eggs that have been deposited in it are hatched.

Fishes, the bones of which are cartilaginous, are long in acquiring their utmost growth; but this is sometimes very considerable. The white shark has often been found thirty feet long, and not less than four thousand pounds in weight. Their strength, too, seems proportionate to their size, and many, with one blow of their tail, can shatter a strong boat and sink it.

Some fishes also live to a great age. The carp which were bred in the ditches of Port-Chartrain, are said by Buffon to have exceeded in age one hundred and fifty years; and those in the Royal Gardens of Charlottenburg, in Prussia, are reported by Bloch to have their heads overgrown with moss. Lodelius alleges, that in some ponds

in Lusatia there are carp about two hundred years old. At Manheim is a skeleton of a pike, nineteen feet in length, and which is said to have weighed, when alive, three hundred and fifty pounds. It was caught at Kayserlantera in 1497; and a Greek inscription on a brass ring, inserted in the gills, announces that it had been put into the pond by the Emperor Frederick II., that is to say, two hundred and sixty-seven years before it was taken. Some species, however, are known to have a much shorter existence; thus, the eel usually lives about fifteen years; the bream and the tench, from ten to twelve; while the stickle-back seldom survives two. The comparative simplicity of their structure, the flexibility of their frame, the strength of their digestive powers, and the equal temperature of the element they inhabit, probably contribute to the longevity of fish; yet with all this they are subject to indisposition and diseases to which they frequently fall victims. The tenacity with which some species adhere to life is remarkable; it is well known that many, particularly perch, may be frozen, and in this condition transported for miles. It appears that their condition, while in this state, is similar to that of what are called hibernating animals, such as the bat, the dormouse, and the marmott, when rendered torpid by the winter's cold—a state resembling sleep—but differing from it in being far more intense, and in involving a greater number of functions. If, when in this condition, fishes are placed in

water near a fire, they soon begin to exhibit symtoms of reanimation; the fins quiver, the gills open, the fish gradually turns itself on its belly, and moves slowly round the vessel, till at length completely revived, it swims briskly about.

Of all migrating animals, fish make the longest journeys, and, in common with all, are probably actuated in doing so by instinctive feelings exciting them thus to seek for food, a comfortable temperature of air, or places adapted for the propagation of their species.

Fish constitutes a considerable portion of the food of men. This is peculiarly the case among savage nations, and the poor of all countries; and hence, it becomes a matter of no small importance to consider the best modes of preserving a regular supply. Embankments and other works upon rivers have contributed not a little to diminish the number of fish, and thus it has become an object with some to localize them in lakes and ponds, and to introduce new species into the country, these being far more easily *acclimated* than either birds, quadrupeds or plants. When fishes are transported from a hot climate, where the waters never freeze, to one where occasionally their surface is converted into ice, they avoid the inconveniences of the change by seeking the depths of the pools. At certain seasons all climates furnish a temperature sufficient to enable them to breed,—a peculiarity which nature seems to have denied both to quadrupeds and birds—and thus great advantages are offered

to those who wish to stock their ponds with the individuals of other climes. In doing so, it is necessary to consider whether the species delight in running or smooth water, and whether they affect a clayey, stony, sandy or muddy soil, or one luxuriant with vegetation. In general, all fresh water fishes delight in lakes that are traversed by currents, and have a bottom of various kinds, such as most large sheets of water afford. Ponds or lakes, with high and rocky banks, are not so fit for acclimating new species, as those in which the banks are low and flat; because they are not so much exposed to the sun, and consequently the temperature of the water is much colder. In preparing a pond for localizing fishes, its bottom and sides are to be provided with wooden boxes or troughs, in which the spawn may be deposited; and the most favorable time to transport them is, when this process is near at hand. If it is wished to introduce many species, it is as well to give to each kind their own peculiar reservoir, adapted to their size and number. After the spawn is deposited, the fishes should be removed by a net from the pond, the boxes are then to be taken up, and the spawn left to be vivified by the heat of the sun. The reason for removing the parent fish at this time is, that their voracious appetite leads them frequently to devour their own offspring, and thus considerably to reduce their number. Another, and a simpler mode of stocking a pond is, to procure and put into it, from other waters, the

stones and plants upon which spawn has been deposited; and in this way fish may be brought out in a warm room. With some hardy kinds, as eels, bream, carp, &c. it is not necessary to take the same precautions as with the smelt and bleac; but, with the greatest care, no one will ever localize fish in any pond which is not previously amply supplied with the food on which they feed. Some, as the vendace, live for the most part upon one peculiar animal; and we can readily account, therefore, for their extreme rarity, and also for the failures which have so often accompanied the attempts to stock a pond with this, as well as many other kinds. Salt water fish can, of course, be preserved in ponds only which communicate with the sea; and the most perfect, indeed I believe the only one of the kind in Britain, is at Logan, the seat of Col. M'Dowal, in Galloway. This was formed in 1800, and consists of an artificial basin of salt water, thirty feet deep, by a hundred and sixty in circumference. The area within, is wholly hewn from the solid rock, and communicates with the sea by one of those fissures or natural tunnels, so common on bold and precipitous coasts. It was formed by blasting the rock, and a barrier was erected at its entrance, formed by a pile of large loose stones, so placed that nothing but water could find egress or ingress.—A neat cottage, for the accommodation of the fisherman, is attached to the pond, which is surrounded by a high wall, at least three hundred

feet in circumference. The labour and expense of this structure must have been considerable, but to two, though very different classes of persons, it affords a very rich treat. Here the gourmand, in the stormiest weather, when no boat dares venture out to sea, finds his appetite supplied; and here, too, the naturalist finds food for his no less insatiate desires, by the opportunities it affords for observing and studying the habits and peculiarities of the briny deep. The pond is excavated eight feet below the level of the sea, and hence there is, when the tide is out, this depth of water in it. During the year 1827, however, the tides were much lower than they had been seen for the previous fifty years, and abandoned the rock which they were never known to have deserted before; the water became stagnant, and the fishes sunk to the bottom, they refused their food, and died in such numbers before relief arrived in the form of a full spring tide, that the pond was nearly depopulated. It is curious to witness the uproar that takes place in the pond the moment the fisherman makes his appearance with his daily store of limpits and other food for his finny charge. The whole surface seems agitated by some vast internal commotion, as hundreds of fishes rush from all corners to one common point, and greedily contend with each other for the delicious mouthful. It is remarkable that they will take nothing but what comes from the sea; if crumbs of bread be thrown to them, though in-

stantly darted at and bolted, they are as quickly rejected. The fisherman's duty is very extensive: he not only plies the net and heaves the line during two or three days every week to supply food for the prisoners in the pond, but he has to keep up the stock, and to select the finest and fatest in his preserve for his master's table. Sand eels, broken crabs and limpits, form their general fare; the former are given raw, but the latter are boiled to separate them from their shells. When ploughing the deep the fisherman keeps a tub of water in his boat, in which, when not much hurt, he places any individuals he may desire to imprison in the pond; and soon a great change comes over them, for they grow fat, and rapidly increase in size and delicacy—a proof that they are not so well supplied when roaming unrestrained among their native deeps and caverns. A selection is easily made of any one fish that may be required, for all take greedily at a baited hook, from which they may be released and restored to the water, without injury, until the desired individual is obtained.*

Although rare with us, salt water ponds were common among the Romans, in which were bred sea trouts, soles, john-dories, and shell fish of various kinds. Lucullus, in order to let in sea water to one of his preserves, had a mountain cut through; and in this preserve, at his death, were so many fishes, that Cato, his trustee, sold them for thirty-two thousand pounds sterling.

* M'Diarmid's Sketches from Nature.

The sale of the fish ponds of Irrius yielded the same price. Cæsar applied to this Irrius, upon some remarkable occasion, to sell him lampreys: this, however, was refused; but, according to Pliny, six thousand were *borrowed* from him. In no article of food were these luxurious people more profuse than in fish; and immense sums of money were frequently given for them. In the reign of Tiberius, two hundred and fifty pounds sterling were given for three mullets, which were brought alive to the dining-room by canals of salt water, running under the table upon which they were cooked in the presence of those who were to feast upon them. Hortensius was more careful of his lampreys than of his slaves. Crassus, the orator, went into mourning for some he had lost; and Vedius Pollio, more than once threw in living men to be devoured by them!

In contemplating the geographical distribution of fishes, we recognize at once the great law which binds all created beings, with the exception of man—munificently set lord over all—viz. that certain species only shall inhabit certain portions of the globe. What a diversity do we observe in the form and organization of fishes, according as they are destined to frequent the rocky coast, the long declivity of the sandy beach, the mud of the river's mouth, the confined channel of the archipelago, the polar ice, or the tropical sea! Nature, in dispensing her creatures over the surface of this great globe, seems to

have imposed limits upon each ; and to very few only has she given the power to live indifferently in opposite circumstances, and under the varied influences of different climates. We can easily understand why quadrupeds which cannot traverse the sea should be confined to particular lands ; and we can conceive, too, that birds, great and wonderful as are their migrations, must from physical causes have a limit to their flight ; but that fishes, inhabiting as they do, a medium, the temperature of which is more uniform than that of the air, and with no obstacles to prevent their progress, or to fix boundaries to their journeyings, still confine themselves in marked zones, beyond which they never pass, except from rare and accidental causes, can be accounted for only on the principle of a law of nature. Some species, accordingly, live within the tropics, under almost every meridian, but do not pass these limits or at most to a very little distance ; others seem to be proper to the temperate or the frigid zones of the northern hemisphere, whilst others again, belong exclusively to the south.

CHAPTER XIII.

ICHTHYOLOGY CONTINUED.—THE HERRING.

THE herring—*clupea harengus* of Linnæus—is distinguished from other fish of the same genus by its peculiar lower jaw, and the seventeen rays of its anal fin. It is about a foot in length, of a dusky green colour above, and silvery beneath. The head is small, the eye large and of a silvery white. Its scales are easily rubbed off; and with the exception of the tail, which is large and forked, the fins are small and of a light colour.

This fish is more generally employed as an article of food than any other: it forms an elegant and dainty dish upon the pompous table of the rich; among the middle classes it is in universal estimation; and with no other "appliances or means to boot" than the boiled potato, it forms a substantial and grateful meal to the poor and needy. We find it in the palace, and we meet with it in the pauper's cabin. It was well known to our ancestors; but, from their ignorance of the means of preserving it, they did not make it, as it now is, an article of commerce.

The very important discovery of the art of salting and drying fish, which has been the means of affording sustenance to myriads, was made towards the close of the thirteenth century, by one William Beuckel of Brabant, who may justly be considered one of the greatest benefactors of the human race; and it is recorded, that one hundred and fifty years after his death the Emperor Charles V. did honour to his invention, by visiting and placing a herring on his tomb. Some say that the secret was communicated to the Flemings by a vagabond Scotsman, who, from some motive or other, had quitted his country; but, whatever truth there may be in this, from that time to the present the Dutch herrings have been held in the highest estimation. The Dutch first engaged in the herring fishing about the year 1164, and were in exclusive possession of it for several centuries; but at length its value became so justly estimated, that severe and obstinate wars between them and the English were the result. This fish is found in the highest northern latitudes that have yet been traversed, and as low as the northern coasts of France,—but with the exception of one instance, where they were reported to be in the bay of Tangier—they have never been discovered farther south than this.

It is the universal opinion, that during winter herrings retire to the northern seas, and that from thence they commence their great migrations to Europe and America, whence, terrified by the numerous enemies with which they meet,

they again return to their northern latitudes, there to remain until they are excited by all-powerful instinct to seek our warmer climes, in order to mature and vivify their countless spawn.

When they first set out, the number of them is so considerable, that they extend over a space of many miles; but meeting with enemies, their numbers are diminished, and they separate into two divisions, the one going to the west, the other to the east. The former pressing onward reaches the coast of Ireland in March, and then turning still more westerly, proceeds to the American coast. The latter taking their course towards the south, again divides into two columns, the one descending along the coast of Norway into the Baltic; while the other, turning to the west, visits the Orkneys and Shetland, where it is a third time divided, one wing taking to the east, the other to the western shores of Britain. But it is needless to pursue this subject, of which much is not known with certainty: surely it is sufficient for us to reflect, with awe and veneration, upon the beneficence of that Almighty Power who has impressed certain instincts upon this most useful of aquatic creatures, which guide and direct them to leave the vast polar seas at certain seasons of the year, that they may visit our shores, and bring with them wealth and food to expecting thousands. There can be no doubt that their instinct leads them to our seas to deposit their spawn. It is an erroneous idea that they come hither in search of food, of which

their countless myriads have deprived the northern latitudes; for they are observed to come to us full of fat, and on their return to be lean and miserable.

The wise regulations of the Dutch have contributed much to preserve the reputation of their herrings, and to multiply the species. Every season each fisherman is obliged to swear that he will not cast his nets before the 25th of June, and when the season is over, he again swears that he has been faithful to his oath. Another law provides, that the fisherman shall cease to ply his nets on the 25th of January; and the fish are thus permitted to cast their spawn uninterrupted and in safety. Hence, the Dutch fisheries are far more productive than those of other nations; for migratory fish universally return to the places where they were permitted to spawn without being disturbed. Another Dutch law enjoins, that the meshes of all herring nets shall be of one size, by which means all small fish escape, and only the large and full grown are captured.

The herring, which is so extensively exposed to the voracity of other animals, belongs itself to the class of voracious fishes. It feeds for the most part upon small entomostraceæ. Newcrantz tells us he has found many small crabs undigested in its stomach; and Lewenhoeck frequently discovered there the eggs or spawn of many species. They seem to be fond of worms; and the Norwegian fishermen often find a worm, which

they call *roe-aat*, in their stomach. Herrings do not all seem to spawn at the same time. The stromling, or small spring herring of the Baltic, appears and spawns when the ice begins to melt, and remains until the end of June; then follows a larger variety of summer herring; and lastly, towards the middle of September, the autumn variety makes its appearance and deposits its spawn.

The herring leads a persecuted life: man wages a perpetual war against it, not only assailing it when it arrives upon his shores, but forming, like the Dutch, large fleets to attack it on the open sea. The whale too, is another enemy which swallows myriads of them; turning himself in small circles, he not only receives vast numbers within his gulf-like mouth, but others, which he disables by the strokes of his mighty tail, he swallows at his leisure. The gull, too, darts among the shoal and devours many, while at the same time, it unerringly points out to the fisherman where to cast his nets, and thus aids in their destruction. Yet no species is so abundant as the herring; and with all the numbers that are the natural prey of other animals, and the myriads that man appropriates to his own use, we do not find this abundance in the slightest degree diminished. Some opinion may be formed of the numbers that are destroyed by man when I state that in the bay of Ranoe, in Norway, about eighty *jagts* are annually taken. One hundred tons make a *jagt*, and each ton contains about twelve hundred

herrings. According to Pontoppidan, in his account of Norway, in the same bay, in one season, nineteen millions of fish were taken. The herring forms a principal part of the food of the Norwegians, and a large branch of their commerce. Many hundred cargoes are annually sent from Bergen alone; and in 1752, between January and October, this town dispatched from it one hundred and thirty-two thousand, one hundred and fifty-six tons.

But these considerations are more adapted to the political economist than to the natural historian. Suffice it to say, that with all attempts to improve the British fisheries, the immense sums expended upon them, the protection afforded to them by government bounties and other means, the Dutch still maintain their superiority over us. I think the cause of this failure is easily to be explained, and quite agree with Dr. Knox, that the superiority of Dutch herrings depends altogether upon their food. This very scientific naturalist discovered that, whilst feeding on the incredibly minute entomostraceous animals, which it more especially affects, the condition of the herring is excellent, rendering it desirable food for man. In this state the stomach seems as if almost empty, although, in reality, it is full of minute animals, to be discovered only by the microscope. The intestines also seem as if empty, and are as free from intestinal and putrescent debris as if it actually fed on nothing but air and water. Whilst thus fed, the herring is in

the very highest condition, and is scarcely inferior to any fish. But as he approaches the shores, thus quitting his proper feeding grounds, he takes to other and coarser food; his condition alters, and his flesh becomes soft and tasteless, the stomach and intestines are found loaded with putrescent remains, and the fish is bad and unwholesome. It is thus that the ill-conditioned herrings caught upon the British shores, however carefully prepared, can never enter into competition with the products of the Dutch deep-sea fisheries. An extensive knowledge of a strictly scientific nature can alone improve this article of commerce; and until laws are formed upon such a basis, rather than on the evidence of men, prejudiced in favour of their own opinions, and biased by their all engrossing and selfish interests, we must be contented to allow to our Dutch brethren the advantages over us which they have obtained.

CHAPTER XIV.

ENTOMOLOGY.

The senses of insects are well known to present, in many cases, most extraordinary acuteness, the details of which not only give inductive evidence of wisdom and goodness, but when brought into relation with those of man, present equally interesting analogical proofs of design—a design which, as I have already stated, I believe to have been at once that of producing harmony throughout creation, and of affording lessons of humility to that most perfect of God's sublunary creatures, to whom the means and the faculty of observation have been given. Upon the admission of this, must depend the analogical arguments in favour of the fact, that the individual happiness of the creature has been produced by the adaptation of its structure to its wants and necessities, and of its place of residence to its habits of life. Is not the contemplation of the fitness of these relations the birth-right of mankind? and, in reflecting on the beings of the external world, on essences which differ from his own, and enjoyments which he can only judge of by comparison, does he not admit that the observation of the habits and manners of living objects—in other

words, natural history—presents the two-fold advantage of bearing analogically upon the habits of human life, and of exhibiting, in the most striking and direct manner, the wisdom and goodness of the Creator?

But it is probably not in our power, since we are thus forced to judge of the senses of insects by a comparison with our own, to appreciate fully the perfection of the former, or the wondrous sources of joy—for there is joy in the free and spontaneous exercise of every sense—which God may have prepared for objects that are among the smallest of his creation. The sounds emitted by many insects—their songs of triumph or of love, the grateful expression of their delight in the lap of bounteous nature, of hearts gladdened by sunshine, and an organization enlivened by the fragrance of flowers, the chirp of surrounding creatures, and the numerically infinite relations which exist between them and the continuous actions of decay and regeneration in the organic world—have from the earliest time, attracted the attention of mankind. The following illustration of this is beautifully rendered from the original Greek of Archias, by Mr. Hay:

'Erst on the fir's green, blooming branch, oh grasshopper! 'twas thine
To sit,—or on the shady spray of the dusky, tufted pine;
And from thy hollow, well-winged sides, to sound the blythesome strain,
Sweeter than music of the lyre to the simple shepherd swain."

Those, too, who loved these "living lyres in

the olive groves sounding all summer long," have celebrated the locust,

> "Soother of loves, encourager of sleep,
> Oh locust! mystic muse, shrill wing'd"—

and the cicada,

> "Cicada! thou, who tipsy with the dews
> Of weeping skies, on the tall poplar tree
> Perch'd swayingly, thyself dost still amuse
> And the hush'd grove, with thy sweet minstrelsy"—

and even the murmur of bees—"the small but not sullen horn of one air-farer, and then of another in succession, but not in pursuit, for each in its instinct is as intent on its own far-off flowers, as if there was not another bee under the sun;"—and of a hundred other songsters of the fir branches, the grass blade and the flower's breast, each and all alive with the sound of winged or shield-clad insects, hymning to the ear of man the praises of their Creator. And that this contemplation was not, even to the ancients, the mere bodying forth of idle imaginings upon the resources of nature, as exemplified in the animal kingdom, but of philosophical observation, is unanswerably attested by the accuracy of all their descriptions of the objects of natural history. Thus we find in Melanger, the source of many of these sounds distinctly alluded to,—"excute facundas pedibus titubantibus alas;" which has been translated by the correct and classic Wilson,

> "Striking thine own speaking wings with thy feet:"

and, it is quite unnecessary to mention how many sweet and touching passages to the same effect, might be extracted from the writings of the poets of our own father-land. The love of nature, and a sympathy with her beauties, spring and ripen, as much from the observation of the smallest creatures, as from the contemplation of the habits and manners of the most noble; and the essence of poetry, all but that which panders to the passions of mankind, consists in a minute perception of the harmony, the beauty and the loveliness, which adorn the face of the earth.

With respect then to the sources of enjoyment to insects furnished by their senses, that they smell there seems to be no doubt, and that the vegetable world affords a most abundant source of enjoyment to the sense of smell, must be equally admitted. Further, the possession of the same sense leads many species to the choice of their food or the pursuit of their prey; while the ejection of fluids of noxious odour is to others, as in the instance of the tenebriæ, a means of defence. That smell is productive of pleasure, is further shewn in the habits of many dipterous and hymenopterous insects, and of most butterflies. Sphinxes and many phalænæ fly about the flowers of lilies and other sweetly smelling plants; and, generally speaking, the most fragrant plants are the most frequently visited by insects of all kinds. The immediate organ of smell in insects is very questionable;

it has been referred successively to their stigmata, their palpi, and their antennæ.

It is said that Clerck, in a discourse held before the Royal Academy of Science, at Stockholm, in 1764, first maintained that the antennæ of insects were their organs of smell. He was led to this opinion by observing that certain beetles when alighting on flowers which were grateful to them, opened the palates of their antennæ; and Bergmann relates, that he has often seen the ichneumon jaculator prying with its antennæ into the holes which contained the grubs of the sphix figuli, as if to smell them out.

Again, the peculiarities of vision enjoyed by the insect tribes in connection with their variety of structure, are at once pleasing and wonderful. Independently of the various directions in which vision may be carried by some tribes, modern discovery has shown, that its minuteness, as contrasted with that of man, is almost inconceivable, and that monadic animals, or such as are microscopic to our ken, are easily visible to the naked eye of insects; and that some insects—more especially the aquatic larvæ—make these monades the chief objects of their chase and nutriment. A new world would be open to eyes capable of perceiving microscopic animals; how distinctly would the curious forms of the tribes of aphides that cling to the rose branch be discerned—yet not more so than they must be by their determined and voracious destroyer, the larva of the hemerobius; how obvious would ap-

pear the precision and regularity of the flight of gnats, weaving their aerial net-work, like a grey cloud of evening, and how perfect and symmetrical would seem the film-like gossamer, as it floats

"Idly in the wanton summer air!"

yet not more so than they naturally present themselves to insects.

The microscopic insects which abound on the surface of the earth, do not appear to be so numerous now as at the early periods of its history, if we except the infusory tribes, which—though as yet little examined—Ehrenberg, the companion of Humboldt in his Asiatic Journey, has lately shown to be repeated under the same forms, in different geographical situations. There are limestones belonging to the middle ages in geognostic chronology, which appear to be almost entirely composed of microscopic shells; and even in more modern formations, the number of microscopic species, independently of their individual preponderance, has been found to exceed that of the species recognized by the naked eye. The myriads of creatures which nature in her prolific and varied means has produced, may to some appear not only accidental but unnecessary; but the relations of all to each other are such, as if interrupted, would break the chain of existence—one of the most glorious and bounteous evidences of design, which can be afforded by the contemplation of the lower orders of creation.

With respect also, to the hearing of insects,

the progress of information on the nature and mode of propagation of sound, brought into connection with considerations on the organization which renders animals susceptible of differences of tone, and those combinations which produce harmony, has made us aware that sound is propagated under circumstances which will render what is very audible to one, scarcely, if at all so, to others, even among men; and it has been still further rendered probable, that there exists an infinite scale of sharp notes, which are perceptible only to certain organizations, suitably adapted for their reception. Thus, sounds may be emitted from numerous tribes of living things, the existence of which could not be detected by our visual organs. Further, certain insects may hear the song of their companions, or the watchword of their mates, and be insensible to the calls of many other tribes; while, on the other hand, the incongruous sounds of the sunny greensward may be all resolved into harmony—a harmony not intended for us—among the choristers themselves. Thus, in the song of insects, and the developement of the sense of hearing, there are analogies with our own enjoyments, which lead us to deduce upon fair and rational grounds, that they were intended for their happiness, and the study of which assists us in marking the goodness and the wisdom of the Creator.

There has been considerable doubt as to the exact position of the organ of hearing, as well as of smell, in insects, and some have supposed

them to be placed in the same organ. Thus, Bonsdorf relates that all his observations agreed in one circumstance, viz. that the antennæ which were folded up in most insects, became erect as soon as they were put on the alert by means of loud sounds, while they disregarded low ones. He observed, in a morning walk undertaken for the purpose of catching insects on the hazels, while standing in the shade, a nut-weevil sitting quietly at a distance on a leaf, with its antennæ hanging down as if asleep; he directed a pocket telescope to the spot, which was about five feet distant, and therefore convenient for viewing the insect. "The point of view being thus determined," says he, "I made a loud sound, and was delighted with the opportunity of seeing the weevil not only roused, but its antennæ which hung down, become elongated, and being full of points struck by the undulations of sound, they extended themselves and remained on the alert, till alarmed again by a fresh sound, the insect fell to the ground, as is the habit of it and other weevils."* But it is to be remarked here, that the impression of the sound having been communicated to the insect, the motion of the antennæ might have followed as an attempt, on its part, to ascertain the proximity or the remoteness of the danger by which it supposed itself threatened; and thus the deductions drawn by Professor Bonsdorf, from the antennæ being put on the alert by the influence of sound, are not at all sa-

* Field Naturalist, July 1833.

tisfactory; nor does even the firm and hollow structure of these appendages, furnished with an arrangement something like that of semicircular canals, leave the subject without many doubts. We must remember further, that spiders which have no antennæ have the faculty of hearing, and that it is not destroyed in grasshoppers after these organs have been removed.

Upon the subject of hearing in general, as enjoyed by insects, Bonsdorf remarks, that the more attentive observers and describers of the honey bee, mention differences in their sounds, such as a humming early in the morning, when the working bees go out upon their flower-choosing excursions; another, when they call forth the whole hive in defence of the state against the attack of enemies; another, when they clear their hives from filth; and another, when the queen bee leads forth a swarm to seek new settlements. "Now," he says, "I ask those who deny hearing to insects, what can be the use of sounds so variously modulated, unless the bees can by hearing discriminate those sounds?"

There is another consideration connected with the life of insects, which I believe was first philosophically advanced by Lord Kames, but has intuitively been admitted by many, which places the goodness of the Creator in an equally strong light:—it is the kind of perception of time which certain insects in all probability enjoy. To the superficial thinker it may appear that the brief existence of many winged insects—

ephemera of creation—coming into life with the morning radiance, and dying with the sun-set, nay, often doomed to live only a few hours, is incompatible with the idea of happiness conferred upon all creatures. It may appear to him that the short enjoyment of the great ends of existence, in insects which vie with the clear and transparent heavens in beauty, their few pleasures when compared with those of animals of higher instinct, and their apparent constant liability to the pursuit of enemies, detract from the evidences of a Father's hand, directing in kindness the various operations in the economy of nature. But is it to be supposed, that time, which is marked in our existence by the chime of a bell, by light and darkness, by youth, manhood and old age, is similarly portioned out to creatures which accomplish the whole purpose of their existence in the space of one day? Is it not more probable that their periods of time, so brief to our perceptions, are, to their view, of long duration, and that the acts of some insect tribes, which to us appear momentary are really to them the work of comparative days, and months, and years?

Thus far then, I have endeavoured to note a few of those points of consideration which bring the faculties of insects into comparison with those of man. They are real analogies, because we cannot form to ourselves the notion of senses enjoyed by the lowest of animate beings, which being similar in their characters to our own, are yet not accompanied by somewhat similar sensa-

tions; and consequently we may fairly draw the inference, that, they are to them not only of the same utility as to us, but also sources of enjoyment, probably even the more distinct and the more powerful, in proportion as they are less disturbed in their simple and instinctive principles by other and higher faculties.

There is another analogy which is generally looked upon as merely imaginative, and yet which certainly deserves some consideration;—I mean the metamorphosis of insects as compared with the life and future destiny of man.

The earliest bards among the human race, and the inspired writers in God's word, drew the same conclusions from the wonderful transformations of insects, doomed to pass through three distinct characters of existence:—that of a grovelling and destructive worm, a mummied and a coffined thing, and a bright and brilliant insect, which seems born of a sunbeam—a very bodying forth of brightness in a living form and shape, adding to its exceeding beauty and elegance, a purity of habits and a simplicity of taste, which contrast as wonderfully with the instincts of its creeping predecessor, as they accord with the exquisite structure of this aerial spangle. From time immemorial the same impression of this analogy has been handed down: and how, I would ask,—not in the spirit of hypothetical speculation, but of humble enquiry—can the lessons of the Redeemer be illustrated by phenomena more striking and appropriate?

If we now turn our contemplations in another direction, and consider the advantages which are derived by the human species from the animal and vegetable kingdoms, we are struck with their intrinsic value in the scale of creation; and, that almost every natural object may be made to increase the happiness and comforts of man. The insect tribes have a much more limited influence than other branches of the animal kingdom, being very seldom used as food, and rarely necessary to the supply of our wants; but still many insects are extensively made use of, and are of very great importance not only in the arts and manufactures, but also in medicine.

It generally happens, that in the adaptation of insect products, we derive benefit from operations carried on in the simple train of circumstances which belong to the developement of insect life; but, when we consider the extent of these operations, viewed as a whole, and not as connected with the life of each individual, we must feel, I think, that the results are connected with those arrangements by which Providence appears to have secured the happiness and welfare of the human species.

I may here instance the caterpillar, which is in the habit of spinning threads which are of considerable utility during its life as a grub, and which, when about to undergo its appointed metamorphosis, it weaves into a little mansion, at once to keep it in a constant temperature, and to preserve it from accidents of wind or weather,

as well as from birds and other animals that might make an easy prey of a being possessing no powers of motion or other means of escape. When considered with respect to each individual insect, the utility of these protections called cocoons, is obvious and simple; but when viewed collectively, we feel inclined to say, that their remote utility is best pointed out in their adaptation to the wants and necessities of man; order and unity will be found characterising every step of the life of insects, and affording direct evidence of wisdom and of goodness in the enjoyments and comforts provided for the creature in its different states, independently of the beauty and immensity of the results which are produced by such simple and curious means.

CHAPTER XV.

ENTOMOLOGY CONTINUED.—THE SILK-WORM.

The silk-worm is the larva or caterpillar of an insect of a tribe of spinning moths, which has been designated by naturalists by the term *bombyx*, a natural family containing some very remarkable species, and distinguished from other tribes by possessing pectinated or comb-like antennæ, and having their wings always incumbent or depressed, while the insect is in a resting position.

The moth of the silk worm belongs to the mulberry tree, and was consequently called by naturalists *bombyx mori.* The beech also, the oak, the pine, the plumb tree, the poplar and many other trees, have each their peculiar species of this family.

The caterpillars of the mulberry moth, commonly called silk worms (*vers à soie*) have a lengthened, and more or less round body, which is smooth in some, while in others it is covered with hair or tubercles. Their jaws act as cutting instruments, and are used to divide the parenchyma of leaves, and beneath the jaws, at the lower part of the head is an opening which contains

the spinning apparatus (*filiere*). The number of feet varies from twelve to sixteen, six of which are placed beneath the first three segments of the body, and are preserved by the perfect insect after a change of form. By means of the thread which they spin, they are enabled to descend from one branch to another, or to reascend, by seizing the silken cord between their teeth, and curving up that portion of the body in which the six true legs are situated. The insect then lays hold of the cord with the last pair, which secures it another fixed point, it then lifts up its head a second time, lays hold of an additional portion of the thread, and, by a repetition of its former action, it gradually ascends to the point which it wishes to reach, and, when safely landed, it disembarrasses itself of the silk which has been collected. These caterpillars are further enabled by the same thread to escape their enemies ; and they never move without taking the precaution of having a thread ready to sustain them in the air, if they should happen to fall.

During their life time they change their skin three or four times ; and, when they have attained their full growth, they spin a cocoon, in which they enclose themselves to undergo their metamorphosis. In the construction of this cocoon, the silk-worm uses silk only, but caterpillars introduce other extraneous bodies, particularly hairs.

I stated, that after a certain period, the cater-

pillar encloses itself in a cocoon, and becomes a nymph, so called, because the insect is then bound up and charged with bands. It is also called chrysalis, from its being gilded and brilliant. It is, however, a mistaken notion that there is any real metamorphosis or transformation undergone by the caterpillar to become a perfect insect; there is a change in form, in feature and in proportion, and in the developement of certain organs of motion, but it appears that all these organs existed in the individual in an embryo state during each stage of its existence.

The life of the silk-worm divides itself into three periods, which cannot be considered without mingled admiration and pleasure. In its first period it is produced under the form of a worm, its body being lengthened and formed by several membranous rings, fitted the one into the other. It then walks with the assistance of sixteen feet; it has a little eminence on the last ring, and its colour is a dirty white or yellowish tint. It changes its skin four times before making its cocoon, which moults are attended with so much danger, that, when educated (to use a term of art) for artificial purposes, they cause a great number to perish. They prepare themselves for it several days previously by ceasing to eat—they seek for solitude and spin a few threads of silk, which they stick to leaves and on their skins. Some days before they are to become a nymph, they choose the most convenient place for their cocoon, and then fix its point of rest, which con-

sist of several silken threads. The second day of labour they give to the cocoon the form which they intend it to take, multiplying the threads and shutting themselves up, and by the third day they are entirely hidden. The day following the caterpillar continues to work in the interior, always with the same thread of silk which it never breaks, and when it has given to its lodging all the perfection that it is susceptible of, it becomes changed into a chrysalis. It has been calculated that the single thread of silk which forms a cocoon, is more than three miles in length.

In this, the second period of its existence, the insect is no longer a worm, but a creature, the limbs of which are all enclosed in one or more enveloping folds, and bent down on its breast, possessing no power of motion. The caterpillar had taken care, in finishing his cocoon, to make one of its ends less solid than the other, and to moisten the silk with a liquid which corrodes it, and thus at the end of fifteen or sixteen days after the change of a caterpillar into a chrysalis, the newly developed moth or insect has only to make a slight effort in order to effect its passage through a cocoon, the tissue of which is in other parts so close that it is almost impossible to tear it.

In the third period of its existence the insect attains all the organic perfection which belongs to the rank in creation that it is destined to fill. The bands of the nymph, chrysalis or aurelia, are broken, and the insect commences a new

life. All its limbs previously bent, soft and without action—"a mass of pap or soft substance, apparently putrified, in which every thing seems confounded"—unfold, strengthen themselves, and are put in action. Supported on six legs, henceforth the insect gently treads the earth, or sustained by light wings covered with a brilliant scaly dust, he as lighty takes his aerial flight. We cannot better assure ourselves of the graduated march of nature, than by the contemplation of these periods of insect life. The same day that they have quitted their cocoon, they are ready to procreate their species; the male seeks the female, soon after which their short career is terminated, and they die worn out. The females also perish almost immediately after laying their eggs.

In considering the life of the silk-worm and its silver winged progenitor, in the relation in which they stand to other insects, and the amount which is allotted to them of animate enjoyments in their position in the scale of creation, one is almost tempted to hold forth the evidences of wisdom and goodness beyond what is directly manifested in that history. But this is not at all necessary; for the argument is comparative, and the amount of power and beneficence must be regarded in connexion with the rank which the animal has to fill. The great proofs of wisdom, every where tempered by bounty, must be derived from a contemplation of the whole of the animal kingdom. It is there alone that we see how great is

the amount of happiness given to each; and when we can thus, in briefly tracing the career and destiny of so small and humble a living thing as the silk-worm, discover a continued design of providing for all its wants, and of enabling it to overcome all its difficulties, how much ought we to admire the goodness that enables us,—while we pass over the imposing evidences of amplitude, magnificence and harmony of design that pervade the whole—to separate a single atom of creation, and in the careful study of its various actions and changes during life, and the means by which they are performed, to find the same infallible proofs of the power, wisdom and goodness of God!

CHAPTER XVI.

CONCLUSION.

ILLUSTRATIONS of the power, wisdom and goodness of the Creator, might be produced from the works of nature, without end;—they meet us at every turn; and to whatever department our enquiries are directed, they flow in upon us in overwhelming abundance. It is well worthy of remark, indeed, as shewing the depth and solidity of the foundation on which rests the existence of a supreme, intelligent and beneficent First Cause, that the farther we push our discoveries, the more clearly are the Divine perfections exhibited. It is not merely true, that on a superficial view we perceive the necessity of believing that a limited and changing world, such as that in which we dwell, could neither exist without being produced, nor be the author of its own existence; and that there must therefore be, beyond the range of our senses, an independent and uncreated Essence, without beginning, without bounds, incapable of change, intelligent, ever active, all-pervading; but it is also certain, that these *primâ facie* views, as they may be called,

are not only uncontradicted, but fully established by the most minute survey of the objects within the sphere of our vision; so that he who penetrates the deepest into the secrets of nature, only multiplies proofs of that most sublime and most animating truth, that "verily there is a God" who made and rules the universe.

To some of these proofs I have adverted, and cursory as my observations have necessarily been, on account of the extensive plan I prescribed to myself, and the desire of being popular rather than scientific, such is the innate force of the evidence, that I do trust no candid man can rise from the perusal of these pages without feelings of religious awe and veneration.

In considering a subject of this kind, however, there is a further, and, I will add, a more important object of which we ought never to lose sight;—I mean the light which natural religion throws on Divine revelation. There are many circumstances which must prevent a reflecting Theist from resting satisfied with the discoveries of the character of the Eternal, which he legitimately deduces from the works of creation.—Among these there is nothing more staggering than the existence of evil. Much ingenuity, indeed, has been employed in proving, that the evils which exist in the world are more than counterbalanced by the advantages with which they are accompanied,—that there are compensations and abatements which frequently turn the scale in favour of enjoyment, even under circum-

stances of the greatest seeming misery, and that, in reference to morals, the very crimes, of which men as free agents are guilty, give birth to virtues in others, which shed a peculiar splendour over the human character; and, if they do not remove the worthlessness of the criminal, at least ennoble the nature which his conduct has a tendency to degrade.

It is vain, however, to deny that, after all, these are nothing more than abatements and compensations. No ingenuity can disguise the appalling fact, that evil, both physical and moral, does exist on the earth, adhering to the condition, and influencing the conduct and destiny of every human being. That there is a preponderance of good, which I am not inclined to deny, may alleviate, but does not remove the difficulty. The question still recurs,—"why should evil exist at all?" And that question, which natural religion cannot answer, gives rise to a long train of similar enquiries, all of them full of gloom and mystery, and all of them beyond the power of unassisted reason to solve.

A well constituted mind, therefore, cannot rest contented with the discoveries which it makes in reading the book of nature. There is still something wanting to its thirst for knowledge and to the satisfaction of its doubts. It cannot be happy amidst the terrors which surround the throne of a half-discovered God, who is seen working every where, but working in clouds and darkness.—Hence the sound and enlightened Theist per-

ceives, with Socrates, that nothing could be more desirable than that the Eternal should break the silence of nature, and proclaim His character and His will to His rational offspring. He is thus prepared for receiving the truths of revelation.

Now, in examining the scriptures, which profess to contain communications from Heaven, we find a most striking analogy between these communications and the ordinary operations of Providence; and, what is more, they afford the very information of which we are in want, and fill up the blank which we discovered in the volume of nature. It is on this view that Butler has founded his celebrated argument in favour of revealed religion; and assuredly it is an argument well calculated to arrest the attention and allay the doubts of a sceptical mind. A philosopher speculating in his closet on the Divine attributes, comes naturally to the conclusion, that a Being of infinite perfection can leave nothing imperfect in His works; but when he descends from these high and abstract musings into the realities of the world in which he lives, an order of things opens to his view, very different from that which he had been led to anticipate. There is a distinct and strikingly peculiar character inscribed on creation. It is a stupendous system, consistent and uniform indeed in itself, but very far from being deducible from *à priori* arguments, or consonant to preconceived opinions. In deriving our ideas of the Creator from the character of Himself which He has caused to be

reflected from His works, we acquire views, undoubtedly more just and appropriate, yet full of obscurity, and embarrassed with many difficulties.

Now, the remarkable peculiarity of revelation is, that, while it exhibits to us the very same character of the Almighty which is to be found inscribed on creation, all its discoveries tend to remove the mystery in which that character is involved, and to clear away the darkness with which nature has surrounded it. This is just what might have been expected in a communication from Heaven, and it tends to give a remarkable credibility to the Divine record. It has an effect on the mind similar, if the comparison be allowable, to that which is produced by the detail of a characteristic anecdote of some individual with whose striking peculiarities we happen to be acquainted. The incident might be difficult of belief if attributed to any one else; but, as soon as the individual is named, conviction is carried strongly to the mind, and we instantly say we believe it, "because it is so like the man."

What then is the pervading and remarkable feature exhibited in the works of nature? The answer is deducible from every department of these works, and cannot fail to have been deeply impressed on the mind in looking back to the survey, superficial though it be, which we have just finished. It is, that these works display a system, not of abstract perfection, but of *contrivances, expedients and compensations*,—con-

trivances to produce beneficent ends—expedients to overcome opposing obstacles—compensations to counterbalance or alleviate unremoved evils. There are *general* laws impressed on nature, and, under all circumstances, rigidly adhered to, —wise, magnificent, universal,—but bearing in themselves qualities which subject all things to change and decay, and which in various other respects lead to calamitous consequences. These general laws were to be dealt with in such a way as to produce a world of animated beings in which enjoyment should predominate. "The problem," as has been strikingly remarked, "was, matter being given, to construct a world."

Here we find materials, often stubborn and apparently unsuitable, moulded and adapted with consummate art to effect some beneficent purpose; we see difficulties the most staggering overcome with amazing skill, and defects which seemed to be incurable, converted, by some simple and unexpected contrivance, into perfections; while the whole system is so admirably combined, and made so beautifully to harmonize, that it is impossible not to acknowledge a power and wisdom altogether Divine. Change, decay and calamity are, as we have said, inherent in the very constitution of nature; and such a state of things seems inconsistent with the permanent welfare of individuals: but here, where contrivances and expedients fail, compensation is introduced. Individuals die, but the species lives;—the destruction of one organized being preserves the life

and contributes to the enjoyment of another,—the passing away of one generation makes room for the next in constant succession,—and thus, without inconvenience, multiplies indefinitely the number of creatures who enjoy the blessing of existence.

Such is nature: and what then is the God of nature? Here philosophy is at fault, and revelation takes up the question. When we are told of man's abused liberty which placed him in the forlorn condition of alienation from his Maker—of his state of discipline, and the means of his redemption, the existence of evil becomes intelligible, and the mystery of nature is unfolded.

There is, indeed, something still dark and mysterious in that decree of the Eternal by which the human race was doomed to guilt and misery, by which the most noble and excellent of his sublunary works, whose head he had crowned with glory, and on whose breast he had stamped an image of his own perfections, should have been permitted to abuse those privileges—to divest himself of the high rank which he held among creatures, and by his follies and crimes to degrade himself below the beasts that perish. While other animals are formed with admirable skill to fulfil the end of their existence, and to be happy up to the extent of their capacities, he would appear to form a melancholy exception to this beneficent order of nature. Formed with feelings susceptible of the most exquisite enjoyment, yet doomed to a perpetual conflict of jarring emotions and

heart-rending cares—endowed with faculties capable of comprehending the most sublime mysteries, yet grovelling in the dust, and expending his powers on empty trifles—glowing with hopes and desires which look beyond the bounds of time and grasp eternity, yet fixing his affections on this little spot of earth, contented with pleasures which perish in the using, and, after dragging out a few miserable and inglorious years, sinking at last into the silent tomb and mingling with the clods of the valley:—such is man in his natural state, fallen, guilty, and mortal; a wretched outcast of nature, and a blot on the face of creation!

But how does revelation explain this dark mystery? It tells us that the present world is not the ultimate destiny of man—that he is here in a state of preparation for immortality, and that, if he is not wanting to himself, he will rise more vigorous and lovely from his fall, assuming a new character, and taking a higher station in the scale of existence; it exhibits the Almighty to us in the character of a Father chastising his undutiful children for their profit, bringing good out of apparent evil, employing sin and death as the handmaids of holiness and immortality, making pain, disappointment and grief the harbingers of eternal joy, and converting the curse which blighted the earth into a blessing.

It is impossible to take up the subject in this light, without perceiving how astonishingly the appearances of nature harmonize with those of

revelation, and how strongly the two systems explain and uphold each other. Indeed, they may truly be said not to be two systems, but only two departments of the same system—the same character is unfolded in both—the same plan of operation—the same ultimate end. The one displays the system in its commencement, the other in its consummation,—the one is the seed, the other the fruit.

In following out this view, we shall find many circumstances of a very satisfactory nature, which bear upon the subject. Among these is the state of the question as to a future period of existence.

When treating of entomology, I cursorily noticed the transformation of insects, as affording an argument from analogy, frequently adduced in favour of the immortality of the soul; but there are other natural phenomena, which also seem favorable to the hopes of a new existence after death. The resemblance between the alternation of the seasons, for example, and the progress and decay of human life, is too obvious to have escaped the observation of any reflecting mind. Spring is the infancy and youth of the year—summer its vigorous and sober manhood—autumn its mellow age, when its fruits are reaped, and its labours are at a close. At last comes winter—cold, desolate and stark—an affecting type of hoary years, and of death;—the leafy honours of the woods are fallen, the flowers and grass which adorned the fields have passed away, the music of the grove has ceased; nature is clad in a

winding-sheet of snow, and every thing seems to indicate that vegetation has run its course, and is annihilated. But, at the voice of spring, nature revives—the sun, which, skirting the verge of the sky, had become feeble and cheerless, resumes its genial influences, and takes a wider circuit in the heavens; young Spring walks forth again in her beauty, gentle zephyrs fan her bosom, flowers spring beneath her feet, and wherever she smiles, the woods and lawns burst into life, and the voice of joy resounds.

May not this be an emblem of the destiny of man? As he undergoes the various vicissitudes of growth, maturity, decay and death, like the productions of the vegetable world; may he not also, like them, hear the creative voice of a new spring, and live?

Analogies of this kind are not indeed so striking as that of those insects, which, after being apparently dead and entombed, rise again, as it were from the grave, and, waving their painted wings, flutter from flower to flower, and seem to live in a new world amidst a paradise of sweets; but they have at least furnished the poet and philosopher with beautiful illustrations of immortality. The truth however is, that the very strongest of these analogies are nothing more than illustrations, and cannot be dignified by the name of solid arguments. They could not be so, even if the analogy were complete; but it fails in its most important point. Go to the tomb of the caterpillar—it is empty. The same body,

which reposed in seeming death, has burst its shell, and has only assumed a new form. Go to the human tomb—the remains of what once was man are still there, mouldering into dust!

But, although neither these analogies, nor any other phenomena of natural religion, amount to a proof that man survives the tomb, yet, when this doctrine has been propagated on the authority of Divine revelation, they come with a very powerful effect on the mind. They shew, in a remarkable and convincing light, the correspondence between natural and revealed religion, and thus form an argument in confirmation of the latter, rather than a proof of that particular doctrine to which they more immediately refer.

But, besides this general adjustment to each other, of the principles of natural and revealed religion, there are some remarkable instances, of a different kind, in which, also, the discoveries of the former give confirmation to the declarations of the latter. I have already adduced one example of this species of confirmation, derivable from the science of geology, in which the truth of the Mosaic account of the flood, and the accuracy of the very period when that awful catastrophe is said in the Divine record to have occurred, are most satisfactorily demonstrated. To geology we are also indebted for other coincidences of a similar nature; and among these there is one, which, although I have nowhere seen it noticed, and although it is rather circumstantial than direct, is very convincing to

my own mind. It is this.—We are informed in the book of Genesis that the age of the antediluvians extended to not less than ten times the age of the present generations of men. We also find, that, from the period of the flood, this extreme longevity began gradually to be diminished, till it reached the present standard, probably about, or soon after the time of the settlement of the family of Jacob in the land of Egypt. It seems a sound inference from this fact, that, from whatever cause, at the time of this great crisis, some new and deleterious property had been communicated to certain substances on which living beings depend for the prolongation of their existence,—that is, to the atmosphere which they inspire, or to the food which they eat. The phenomenon recorded, agrees, at all events, with this hypothesis, as the strength of the human constitution seems to have been gradually undermined, till it reached its minimum. Along with this scriptural fact, I should be inclined to place that of the existence of giants in the very early ages after the flood, were I not doubtful, on the critical grounds stated in another part of this work, whether or not the various words translated "giants" were really meant to indicate men of extraordinary stature.

What then are the geological facts that seem to bear out the statements to which we have alluded? It must appear obvious, that the only evidence of this kind which we can expect, must be indications of the existence of a state of things

before the deluge, better adapted for the maintenance of animal life, accompanied, in all probability, with a salutary influence on the vegetable world. If, on examining the remains found in the *detritum* of the latest formation, we should discover proofs that animals now confined to tropical regions, for example, had been at the period of the flood spread over the temperate zone—that creatures of a larger size than now exist on our globe, then brouzed on its herbage, or devoured its less powerful inhabitants—and if, in addition to this, it should appear that the earth was more prolific, or nourished plants of more luxuriant growth, we should then be in possession of a variety of facts, all confirmatory of each other, and pointing to one conclusion, namely, that there was, during the antediluvian era, a vigour in the powers which support organized existence, unknown to the world in its present state; and hence we should derive a very powerfnl argument in favour of the credibility of the fact recorded in the Bible, which the infidel has held up to such unsparing ridicule, that the life of man was, in its primitive state, prolonged far beyond the period which it can at present attain.

Now, that this state of things did actually exist, there are various and very remarkable indications. By the researches of geology, the original existence of tropical plants and animals in our temperate zones has been put beyond all dispute: fossil remains of creatures of amazing size, the species of which are now extinct, and of gi-

gantic races of existing quadrupeds, are spread over the face of the earth; and among the diluvial relics of the vegetable kingdom are found various kinds of plants and trees, of very superior dimensions, which seem to have been fostered in a climate and soil more genial than which is now experienced in any part of the globe. I do not know where we could seek for evidence of a superior vigour in the powers of life, during the antediluvian period, if we deny it in such instances as these.

There is something very satisfactory in this kind of testimony borne to the truth of the sacred scriptures. It comes upon us unexpectedly, and is entirely without suspicion; and while, in this one instance, it proves the futility of an infidel objection boldly urged, it throws discredit upon other objections of a similar nature, against which no such evidence has hitherto been brought. If the discovery of extinct species of enormous animals, such as the mammoth, megatherium, megalonyx, and gigantic tapir, and of the fact, that tropical animals, such as the tiger, hyena and hippopotamus, existed, during antediluvian times, in regions, which, from the coldness of the climate, are now altogether uncongenial to them, as well as indications connected with other kindred geological phenomena, rebuke the presumptuous sneers of the infidel as to the original longevity of the human race asserted in the Divine record, it seems fair to infer, that in instances where the refutation is not so complete,

the defect must lie in our own ignorance of the operations of Providence, and not in the word of God; and hence the argument extends in its conclusions far beyond the isolated fact which it is brought to establish.

On the whole, although it be true that natural theology is something distinct from revealed theology, yet the enquiring mind cannot fail to perceive, not only in the discoveries which the former makes, but also in the very deficiences which it exhibits, such circumstances as form a most powerful auxiliary to the argument in support of the latter; and he, who has attended with a candid and intelligent mind to the light which the progress of science and human research has thrown, and is throwing, on this most important of all enquiries, can find no reason to doubt, that, in the further advancement of knowledge, difficulty after difficulty will disappear, and revealed religion will be ultimately found, in all its truths and in all its bearings, to correspond with the discoveries of the naturalist, and the clearest dictates of sound philosophy.

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